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NOTICE.

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GNATS, MIDGES AND MOSQUITOS.—III.

By E. A. BUTLER.

IT is difficult for a stay-at-home Englishman, used only to the minor inconveniences caused by insects in this highly denaturalized country, to conceive the horror with which Gnats and Mosquitos are viewed in those more primitive regions in which they still exist in incredible multitudes, and to realise the terrible sufferings they are answerable for; he is inclined to treat the whole matter almost as a joke, and to laugh at the violence of the execrations which have been heaped on the heads of such insignificant offenders. But there can be no question that the plague has been and is still, in many parts of the world, a most real and serious one, and experience shows that the descriptions travellers have given of the numbers of the insects, and the pain and disfigurement caused by their attacks, highly coloured though they often seem, may yet be accepted as having a solid foundation in fact. The exact effect of a Gnat or Mosquito bite, however, upon the human body, varies with the species of insect which produces the wound, with the sensitiveness and temperament of the individual attacked, and with surrounding circumstances. On the borders of the great rivers of the Brazilian forest, where Mosquitos are probably as troublesome as anywhere in the world, the effect is quite different upon Europeans and natives. According to Humboldt, who paid great attention to the subject when he was in the region of the Upper Orinoco, blisters and swelling are not produced upon the skin of the natives, *i.e.*, the copper-coloured Indians, though such results follow in the case of the white man, new settlers being much more severely dealt with than old residents. Speaking of a white man who had had "his twenty years of Mosquitos," he says, "Every sting leaving a small darkish-brown point, his legs were so speckled that it was difficult to recognise the whiteness of his skin through the spots of coagulated blood." That, notwithstanding their immunity from the above secondary effects, the natives still suffer acutely, is manifest from the numerous and energetic devices they adopt to free themselves from the plague, as well as from the extent to which the Mosquitos form a staple subject of conversation. Elevated platforms have been resorted to as retiring places, since the flies are most numerous near the ground, the greater number not rising above 15 or 20 feet; a calico tent suspended from the branches of trees when in the forest, is another device, while indoors there are the well-known nets and curtains. Humboldt speaks of his boatmen as vigorously slapping one another's bare backs to drive away the tormenting insects, and as getting so used to the action that they sometimes slapped themselves in their sleep; some rubbed the wounds on their comrades' backs with rough bark (!) or again, the women patiently set themselves to pick out from the pustules the drops of coagulated blood. "How are you with regard to the Mosquitos?" was a common form of salutation, while, to the native mind, the absence of Mosquitos formed the highest conception of the bliss of heaven. "How comfortable must people be in the moon," said an Indian to his European teacher, "she looks so beautiful and so clear, that she must be free from Mosquitos!"

Dr. A. R. Wallace, visiting the same region, says: "Immediately after sunset they poured upon us in swarms, so that we found them unbearable, and were obliged to rush into our sleeping-rooms, which we had kept carefully closed. Here we had some respite for a time, but they soon found their way in at the cracks and keyholes, and made us very restless and uncomfortable all the rest of the night." And so far from getting used to them: "After a few days' residence we found them more tormenting than ever, rendering it quite impossible for us to sit down to read or write after sunset." The people used dried cow-dung burnt at their doors to keep away the insects, and this seemed the most effectual remedy, so that by adopting it, and walking about at the same time, the explorer managed to "pass an hour pretty comfortably." Mr. H. W. Bates, speaking of Fonte Boa, also in the same region, says that, "in addition to its other amenities, it has the reputation throughout the country of being the headquarters of Mosquitos, and it fully deserves the title. They are more annoying in the hours by day

than by night, for they swarm in the dark and damp rooms, keeping in the daytime near the floor, and settling by half-dozens together on the legs. At night the calico tent is a sufficient protection, but this is obliged to be folded every morning, and in letting it down before sunset great care is required to prevent even *one* or *two* of the tormentors from stealing in beneath, their insatiable thirst for blood, and pungent sting, making *these* enough to spoil all comfort." From these extracts we see that the experience of the traveller in South America is by no means uniform, and this partly results from there being several distinct species of flies concerned in these attacks, some inhabiting one stream and some another, according to the character of the water, and having also their time of flight at different hours of the day and night. These peculiarities were particularly noticed by Humboldt.

Mungo Park considered that crocodiles were but of little account to the traveller in Africa, "when compared with the amazing swarms of Mosquitos, which rise from the swamps and creeks in such numbers as to harass even the most torpid of the natives." With his clothes almost worn to rags, he was ill prepared to resist their attacks, and frequently, therefore, passed the night walking backwards and forwards, fanning himself with his hat, perpetual motion being necessary to keep them at bay. Linné testified to their extraordinary abundance in Lapland, where smoke and grease were in his time, as they probably are still, the best preventives known. And in recent years, Nordenskiöld and others have recorded meeting with enormous swarms in high Arctic latitudes, in which regions, indeed, it is not only *Culices* that exist in myriads, but other *Diptera* as well. For instance, Dr. F. A. Walker, speaking of a visit to Iceland, mentions not only that blue-bottles were to be found in great numbers on rotting fish everywhere, but especially that the little black flies that frequent seaweed on the sand flew in multitudes on board the steamer, blackening the windows of the deck saloon. Dr. Clarke, travelling in South Russia, tells a pitiful tale of the persecutions to which he was subjected in passing through a morass which teemed with Mosquitos to such an extent that a lamp which was lit in a closed carriage was soon extinguished by the swarms that flew into it.

As may be imagined from their habits and life-history, Mosquitos are not equally distributed in the countries in which they occur; in low-lying, marshy districts they are most abundant, but as one recedes from the water, or reaches greater elevations, they become less numerous. They attack not only human beings, but also cattle, and hence the proximity of the latter in places much infested may sometimes give relief to men; on the other hand, they have often been noticed accompanying cattle on their return from marshy pastures, clustering round them and thus becoming ultimately introduced into houses. It has been said that they object to the strong smell of the alligator, but if this be so, they can overcome their dislike when there is a chance of a draught of human blood, for Humboldt relates that while dissecting a large alligator, 11 feet long, the odour of which infected all the surrounding atmosphere, he and his assistants were fearfully stung. From the method of life of the Mosquito, especially in its early stages, it is clear that it would be next to impossible to transport them accidentally, except as perfect insects, from one country to another across large tracts of ocean, and the reports that are sometimes spread of Mosquitos appearing in hotels in this country frequented by Americans need to be received with great caution. Probably, in most instances, investigation would show that they were simply English Gnats rather more virulent than usual, which had been propagated in some neighbouring cistern or pond.

Opinions have differed as to the cause of the swelling and pain resulting from a Gnat or Mosquito bite. Some have maintained, in accordance with what has always been the popular belief, that effects of such magnitude could not be produced without the introduction of a poisonous fluid, though they have failed to show that any apparatus exists which would be capable of completely fulfilling such a function. Though this poisonous fluid is itself conjectural, a purpose has been assigned to it, viz., that of rendering the blood more liquid, so that it may the more easily be sucked up. And that some such function would have to be assumed is tolerably certain, since the poison could hardly be regarded merely as an implement of offence, and consequently an advantage to its possessor. It seems scarcely open to question that, apart from some such function for the poison as above, the insects could far more easily obtain the blood they covet, and far less precautions would be taken against them, if they did not produce any painful results and thus rouse the hostility of their victims, and that therefore, from that point of view, a poison could not be an advantage. If, therefore, a poison exists, its function must undoubtedly be to facilitate the drawing of the blood, and not to serve as a weapon.

Influenced by the anatomical difficulties above mentioned, other observers have maintained that no poisonous fluid is injected, but that the laceration of tissues produced by the six minute, acutely pointed, and in some cases barbed organs which constitute the borer, is sufficient to account for the inflammation and itching. This hypothesis, again, is not without objection. It would appear that the insect sometimes experiences difficulty in getting at the blood it desires, for deep perforations of the skin may be made without drawing blood, and then no swelling occurs, and little pain is felt; this certainly appears a formidable difficulty in the way of the latter explanation. Mr. G. Dimmock, one of the most recent experimenters with *Culices*, forcibly says: "I am convinced that there is use made of a poisonous saliva, for when biting, if the Mosquito fails to draw blood, which it often does on parts of the back of my hand, it may have inserted its proboscis nearly full length in from one to six directions in the same place, and withdrawn its proboscis; indeed, it may have inserted its proboscis, as often occurs, in extremely sensitive parts, yet in such cases, if no blood be drawn, no more effect is produced upon my skin than is produced by the prick of a sharp needle: a red point appears, only to disappear in a few hours. Certainly there has been as much tearing of tissues in such a case as above mentioned as there is when the Gnat settles on a place richer in blood, and with a single probing draws its fill." He remarks also that "the poisonous effect on me, as proved by numerous experiments, is in direct proportion to the length of time which the Gnat has occupied in actually drawing blood," and argues, perhaps somewhat inconsequently, that this indicates the constant outpouring of some sort of poisonous fluid during the blood-sucking process. But notwithstanding this, he was unable to detect any channel for the conveyance of poison into the wound. And, moreover, it is difficult to conceive of a double flow of liquid-poison downwards and blood upwards—as taking place simultaneously within the narrow compass of the proboscis of a Gnat or Mosquito. Or, again, if the movements were not simultaneous, but a downflow of poison were followed by an updraught of blood, it would seem that the greater part of the poison would be sucked out of the wound almost as soon as it was instilled, and that, therefore, it could hardly exercise much influence upon surrounding tissues. Hum-

boldt, who was a firm believer in the poisonous nature of the bite, considered this sucking out of the poison to be the explanation of the painlessness of some wounds. His experience was almost the reverse of that of Mr. Dimmock, as detailed above. He affirmed that if the insect were allowed to suck to satiety no swelling took place, and no pain was left behind, and considered that when pain was produced it resulted from the hasty interruption of the process of sucking, since then the last infused poison would not be able to be withdrawn. He experimented with one of the most virulent species, allowing it gently to settle on the back of his hand, and reports of it: "I observed that the pain, though violent in the beginning, diminishes in proportion as the insect continues to suck, and ceases altogether when it voluntarily flies away." The following experiment, however, seems to throw some doubt on the poison theory altogether. He says: "I wounded my skin with a pin, and rubbed the pricks with bruised Mosquitos, and no swelling ensued." On the whole, therefore, it must be admitted that great difficulties beset both of the two hypotheses that have been commonly advocated in explanation of the swelling and pain consequent on the bite. Of course similar remarks would apply in the case of both bugs and fleas.

There seem to be chiefly two species of true Gnats that infest houses in this country, which are named *Culex annulatus* and *ciliaris*. The former has pretty spotted wings, but must not be confounded with another spotted-winged Gnat-like fly (Fig. 4) which is frequently found in windows, and is generally called the "window Gnat" (*Rhyphus fenestralis*). The specific name *fenestralis* (from Latin *fenestra*, a window) was given to it in consequence of its usual habit of flitting about windows. It belongs, however, to a different family, and its habits and life-history are totally unlike those of the true *Culices*. Its larva is terrestrial, not aquatic, and lives in dung. *Culex ciliaris*, specially known as the "House Gnat," is a reddish-brown insect, with greyish wings.

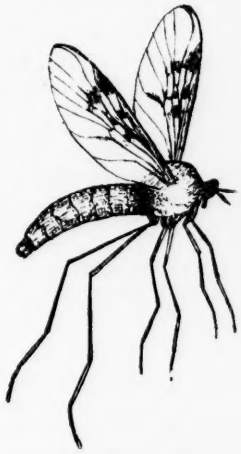


FIG. 4.—WINDOW GNAT (*Rhyphus fenestralis*).

The *Culices*, or true Gnats and Mosquitos, are not the only "thread-horned" flies that trouble mankind by sucking blood, though they are usually the chief; it is difficult, however, to give definite popular names for the other species. The word "Midge" is perhaps most commonly used as a general term for them, though it is also employed for insects of similar structure but of less annoying habits. To the genera *Simulium* and *Ceratopogon* belong some of the most annoying of these persecuting Midges, and some of the former become occasionally almost as bad a plague as the Mosquitos proper. The *Simulia* are also known as "sand flies," and in America, where they have occasioned great annoyance and trouble amongst the cattle, they are called "Turkey Gnats" and "Buffalo Gnats." They are small, dark-coloured insects, of a less fragile nature than the *Culices*, but still "thread-horned," and not therefore to be confounded with any of the "short-horns," such as the great, stout-bodied "breeze-flies," which are also terribly bad stingers. The flies have the peculiar habit of emerging from the chrysalis beneath the surface of the water. The *Ceratopogon*, which is sometimes troublesome in this country, is a minute greyish-brown insect; it is sometimes abundant in marshes and fens, where the females are very annoying.

But besides these, many other insects are called Midges, though they are not troublesome. There are, for example, first, the *Chironomi* or Plumed Gnats, the larvæ of one species of which are the grotesquely wriggling red, worm-like creatures, found in ponds and water-butts, and called "blood-worms." These are more uniformly cylindrical than the larvæ of the *Culices*, and besides wriggling about in the water, they construct amongst the mud at the bottom, tubes composed of particles of decayed leaves, fastened together with silken threads. The pupa, which is similar in shape to that of the *Culices*, and has an enormous fore-part, may be distinguished by the pair of exquisite white plume-like tufts that project from the sides of that part of the body. Each consists of five hairs, which are delicately fringed, so that the whole makes a large rosette. The pupa usually lies at the bottom helplessly, though it can swim, if obliged; a few hours before becoming a perfect insect it mounts to the surface to prepare for the change. The perfect insects are called "Plumed Gnats," because of their beautiful antennæ, which are even more deeply feathered than those of the *Culices*. They have no long beak, and are not adorned with scales like the true Gnats. These *Chironomi* form in the air dancing swarms which usually consist chiefly of males. Then there are the "Winter Midges" (*Trichocera*) which form little hovering swarms on bright days during winter and spring. These again are quite different from the Gnats, and belong to the daddy-longlegs group. The last "Midges" to which we shall refer are the family called *Psychodidæ*, most exquisite, though minute creatures (Fig. 5), some of which are commonly found in houses, on the walls, or running in little zigzags up and down the windows. They too are "thread-horns," but can be easily distinguished from the others by the peculiar shape and adornment of the wings. These are lancet-shaped, and are thickly covered with hairs, often so distributed as to form a pretty pattern, and this, coupled with the fact that they rest with wings not crossed over their backs as Gnats do, but spread out and sloping backwards at their sides, causes them to look like tiny moths. They are harmless little creatures, and their larvæ live in dung.

FIG. 5.—MIDGE (*Psychoda*).

THE MINERALOGY OF METEORITES.

BY VAUGHAN CORNISH, B.Sc., F.C.S.

AT various times and places, solid bodies of either a metallic or a stony character have been observed to fall from the sky, the occurrence, from circumstances of time and place, having evidently no connection with volcanic eruptions.

These bodies, termed Meteorites, possess peculiarities of mineral composition and structure which alone would serve to place them in a class apart from the ordinary rocks of the earth's surface. There are, however, differences of character among Meteorites themselves; which are for convenience classed as—

Siderites, Siderolites, Aerolites,

according as they are composed principally of metallic constituents (iron alloyed with nickel), of metallic and

stony constituents together, or, as in the case of aerolites, of stony minerals with no uncombined metals. The first class, Siderites, contain from 80 to 95 per cent. of nickeliferous iron. The most important characteristic of the first class is this constant association of nickel with the iron, and the peculiar crystalline structure known as Widmanstätten's figures, which are revealed when a specimen is cut, polished, and then submitted to the action of dilute nitric acid. A prominent peculiarity of the stony Meteorites is their *chondritic* structure, that is, they are composed of round grains imbedded in a ground mass of similar composition.

All Meteorites have a varnish or glaze on the surface, produced by their rapid passage through the air. This glaze shows that the surface has been subjected to a heat so intense as to fuse the material. The glaze is always very thin, pointing to the fact that the heating has been of very short duration, and has not had time to affect the inner portions.

Such are the chief features of the bodies which have been *seen* to fall from the sky. Now and again, in different parts of the globe, specimens are found on the surface which show the same well-known characters. These fragments are often found at a distance from any rocks having the least resemblance to them in mineralogical character, and where there is no evidence of transport by ice or water as in the case of boulders. Such specimens are placed in museums under the class "Meteorites," and in many instances the evidence is sufficiently cogent to leave no practical doubt of their origin being identical with that of the Meteorites the fall of which has been actually observed.

A very slight examination of the circumstances attending the fall of Meteorites, as, *e.g.*, their high velocity, is sufficient to show that they are not ordinary falling bodies, but that they have come from regions outside the Earth's atmosphere. Whether their ultimate origin is terrestrial, or from some other member of the solar system, or from regions beyond that system, it is not so easy to decide. The view which finds most general acceptance is that the Meteorites, like certain systems of shooting stars, move in orbits similar in form and range to those of the comets. Their supposed ex-terrestrial origin gives a certain fascination to the study of Meteorites. Viewed in the light of visitors from other worlds than ours, the comparison of their materials with the materials of our own earth becomes a matter of the highest interest. Hitherto, some four-and-twenty of the already-known chemical elements have been recognised in Meteorites, and no new element has been found in them. The principal elementary constituents are—

Iron,	Phosphorus,
Nickel,	Sulphur,
Magnesium,	Carbon,
Calcium,	Oxygen,
Aluminium,	Silicon.

The following occur in smaller quantities :—

Cobalt,	Titanium,
Manganese,	Lithium,
Chromium,	Sodium,
Copper,	Potassium,
Tin,	Hydrogen,
Antimony,	Nitrogen,
Arsenic,	Chlorine.

Of these nitrogen and hydrogen occur in the uncombined state as occluded gas. Carbon occurs uncombined, as graphite, as well as combined with oxygen. The following is a list of the mineral species which have been identified in Meteorites with the chemical formulæ as given by P. Groth (*Übersight der Mineralien*). The names in italics indicate species which have not been recognised among naturally-occurring terrestrial minerals. Of these Schreibersite, Lawrencite, Rhabdite and Troilite have been reproduced in the laboratory.

Anorthite, Si_2 Al O_8 Al Ca.

Augite and Diopside $(Si\ O_3)_2$ Mg Ca ; or, $(Si\ O_3)_2$ (Mg, Fe) Ca.

Breunnerite, C O_3 (Mg, Fe).

Chromite [(Cr, Fe) O_2] (Fe, Cr).

Daubréelite $(Cr\ S_2)_2$ Fe (crystalline form not determined).

Enstatite and Bronzite (Mg, Fe) Si O_3.

Hornblende $(Si\ O_3)_2$ $(Mg, Fe)_3$ Ca $(Si\ O_3)_2$ } $(Si\ O_3)_2$ $(Mg, Fe)_2$ Al_2 $(Al\ O_3)_2$. }

Labradorite, Si_2 Si O_8 Al Na. } Si_2 Al O_8 Al Ca. }

Lawrencite, Fe Cl_2.
Readily prepared in the laboratory, but rapidly oxidizes, hence probably its non-occurrence in nature under ordinary conditions.

Magnetite $(Fe\ O_2)_2$ Fe.

Maskelynite [Si O_3]$_4$ Al_2 (Ca Na_2 K_2).
Crystallizes in the cubic system.

Oldhamite, Ca S.
A readily oxidizable body, not occurring in nature under ordinary conditions.

Olivine, Si O_4 $(Mg, Fe)_2$.

Osbornite,
? An oxysulphide of Titanium and Calcium.

Pyrrhotite, Fe_{11} S_{12}.

Rhabdite, Fe_7 P.
Reproduced by passing the vapour of Phosphorus over red-hot iron-wire. Crystallizes in the quadratic system.

Schreibersite, ? (Fe Ni Co)$_3$ P.

Troilite, Fe S.
Apparently identical with the product obtained by heating together iron and sulphur. Crystalline form not determined.

Trydimite, Si O_2.
Trydimite is a form of silica not produced in presence of water (as quartz), but by igneous fusion.

Graphite.

Alloys of Nickel and Iron.

Hydrogen, nitrogen, carbonic acid and carbonic oxide as occluded gases.

Certain soluble salts, occasionally, as the chloride and sulphate of sodium, and the sulphates of calcium and magnesium.

The first information as to the mode of formation of the minerals occurring in Meteorites was afforded by the researches of Dr. Sorby. He made use of the method of studying the *inclusions* which may be seen in crystals when examined in thin section under the microscope, a high power being generally used (*Q. J. Geol. Soc.*, 1858). By the study of artificially produced crystals, he established the following facts :—

1. That when substances crystallize out from aqueous solution portions of the liquid are included in the crystal, forming liquid cavities or inclusions. If the crystallization take place at a high temperature the liquid on cooling contracts, leaving what is generally termed a gas bubble. This bubble is free to move. Sometimes the bubble is vacuous, sometimes it contains a gas such as carbonic acid found in the cavities in quartz.

2. When the nature of the liquid magma, from which a substance crystallizes is such that it solidifies at the

ordinary temperature of the air, the appearance of the inclusions is very different. Thus silicate of iron, which frequently crystallizes out from the molten slag of copper works, shows *glassy* inclusions with *stationary* bubbles. Sometimes there is more than one bubble, which could not be the case with a liquid inclusion. In the case of a glassy inclusion with a bubble, the magma has cooled and contracted, leaving a bubble, and solidification has ultimately taken place, whereby the bubble has become fixed. If, however, the whole crystal be heated the included slag melts, the bubble becomes movable, and generally disappears when the temperature has been raised to that at which crystallization took place, the liquid having now expanded so as to occupy the whole of the cavity.

3. Crystals of other substances show *both* glassy inclusions and inclusions containing water. In such cases the temperature of formation was high, since the now solid magma was then liquid, and the crystallization must have taken place under great pressure, otherwise the water found in the liquid inclusions would have been in the state of vapour.

4. Lastly, in crystals formed by sublimation (*i.e.* where the substances change at once from the gaseous to the solid state without passing through the intermediate condition of a liquid), the inclusions are stationary gas bubbles bounded by the actual substance of the crystal itself.

The type of inclusion serves therefore to show by what process the crystal was formed. The processes obtaining in the formation of the crystals occurring in eruptive rocks and in mineral veins are—1. Formation from aqueous solution. 2. From igneous fusion. 3. The last two combined, which can only happen under great pressure. 4. Formation by sublimation. In studying the inclusions in the minerals of Meteorites, Dr. Sorby found glassy inclusions *only*, neither liquid nor gaseous inclusions being observed. This would appear to show that the Meteorites examined were formed by the process of igneous fusion pure and simple. This conclusion was confirmed in 1866 by Daubrée (*Géologie Experimentale*). His reproduction by the method of igneous fusion of rocks showing many of the characteristic minerals of Meteorites has been referred to in a former article (KNOWLEDGE, *July*, 1891). The brecciated structure of Meteorites, indicative of violent mechanical disturbance or of the agglomeration of heterogeneous fragments, was of course not shown by the products of the crucible. It is principally in such peculiarities of structure and of mode of aggregation of minerals that Meteorites differ from some of the more basic eruptive rocks, such as the diamond-bearing rock of Kimberley. Most nearly approximating to the siderolites and aerolites are the so-called volcanic bombs which are floated up with the liquid lava in eruptions, probably from great depths below the earth's surface.

Till recent years native iron was believed to occur only in Meteorites, and the constant association of the metal with nickel was regarded as another peculiarity of these bodies. It has, however, now been shown pretty conclusively that the native iron, found in large masses by Nordenskiöld in the Island of Disco, are of telluric origin, having in all probability been left by the weathering away of the basalt which occurs in the locality. This basalt, which belongs to the class of the more basic rocks, is found to contain nodules or balls of iron, sometimes nearly three-quarters of an inch in diameter. This iron (as in Meteorites) is alloyed with nickel, and shows the Widmanstätten figures. It is still undecided whether the basalt contained the metallic matter when in the molten condition before eruption, or whether the presence of the free metal is due to the reduction of silicate of iron by passage through beds containing carbonaceous matter such as are found in the vicinity.

According to a theory which is advocated by more than one eminent astronomer, Meteorites are *bombs* of ancient terrestrial volcanoes, shot into space in bygone ages, and revolving round the sun in orbits intersecting that of the earth, and hence one by one encountering the earth, of which they thus become once more a part. This theory of the origin of Meteorites has many points of advantage over those which refer them to the action of volcanoes on other members of the solar system. One point only will be mentioned here—namely, that of bodies shot out from any other planet, only an exceedingly small proportion would intersect the orbit of the earth, whereas bombs from a terrestrial volcano would *all* intersect this path.

Notwithstanding the ability with which this theory has been advocated, the view is still generally held that Meteorites come from the further realms of space, moving in cometary orbits, either parabolic or elongated ellipses. It is true that trustworthy determinations are wanting of the velocity of Meteorites in the highest regions of the atmosphere, determinations which would probably furnish conclusive evidence on this point; but the paths which Meteorites follow appear to be cometary rather than planetary, in that they do not show any definite relation to the ecliptic. Several cases have been known of the fall of Meteorites during a shower of shooting stars, though they have not been satisfactorily traced to the radiant of the shower.

The question of the existence elsewhere than on our own planet of the conditions necessary to life, as life is known to us, is a subject which cannot fail to excite interest. The mineralogical examination of Meteorites has confirmed the evidence of the spectroscope, that carbon, the element which appears essential to life on the earth, is present elsewhere than on our own planet.

SWIMMING ANIMALS.

By R. LYDEKKER, B.A.Cantab.

(*Continued from page* 154).

WITH the Fishes, which, with the exception of the Whale, are perhaps, of all animals, the most beautifully adapted for rapid motion through the water, we enter the great group of Vertebrates. The contour of an ordinary fish, such as the Perch (Fig. 3), is modelled on those lines suited for cleaving the water best, through which

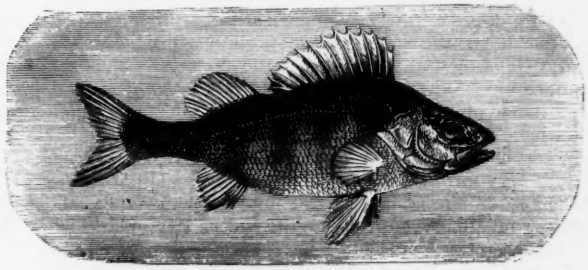


FIG. 3.—THE COMMON PERCH.

the fish is propelled mainly by the muscular tail with its terminal fin. The fins on the body act mainly as balances, although aiding to a certain extent in propulsion. These body-fins in all fishes are of two types, namely—paired and median. The number of paired fins is two, the front pair corresponding with the fore limbs, and the hinder pair with the hind limbs of quadrupeds. In the Perch (Fig. 3), the front or pectoral pair of fins are seen immediately behind the head; the second or pelvic pair being placed below and slightly behind the pectoral ones. In many other fishes (as in Fig. 4) the hinder pair of fins occupy, however, a position corresponding with that of the hind limbs of quadrupeds. The pectoral fins, although assisting to a certain extent in the motion of the fish through the water, act rather in directing its course than as propellers. Their chief function is, however, to maintain the balance of the body in the water; a fish which has lost one of these fins falling over to the opposite side. It will be observed from Fig. 3 that the pectoral fin of a Perch (as well as of most of our existing fishes) consists of a number of rays spreading out in a fan-like manner from the point of attachment to the body. A totally different arrangement obtains, however, in the pectoral fin of the extinct fish represented in Fig. 4. Here it will be seen that the fin consists of a central lobe covered with scales, from the edges of which the fin-rays project as a deep fringe. This more primitive type of fin is indeed very common among the extinct fishes of the Palæozoic rocks, and still persists in the Barramunda of the Queensland rivers, a figure of which was given in the article on "Mail-Clad Animals." The more important median fins are the dorsal on the back, and the anal in front of the tail. In many fishes (Figs. 3 and 4) there are two dorsal fins, one in front of the other; the front one being often large and spiny, and the hind one small and soft (Fig. 3).

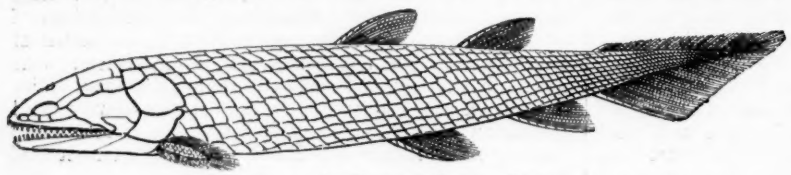


FIG. 4.—AN EXTINCT GANOID FISH.

The tail and tail-fin form, as we have said, the chief propeller of the fish; and it will be particularly noticed that the position of this fin is vertical. In swimming, as we may observe in an aquarium where fish are kept, the tail is rapidly and strongly bent from side to side, while the two lobes of its fin have an undulating motion, and thus act like the blades of a screw-propeller. A difference between the structure of the tail-fin in the two figured fishes recalls the one already noticed in the pectoral fin. Thus in the Perch (Fig. 3) the scaly part of the tail ends in an abrupt and almost straight edge, from which the rays of the fin form a nearly symmetrical fork. In Fig. 4, on the other hand, the scaled part of the tail is produced to a point, extending far back among the fin-rays, which are arranged unsymmetrically along its two edges. It is this latter mode of arrangement which is the older and more primitive.

In certain fishes which depart more or less widely from the ordinary form there is a corresponding modification in the shape and functions of the fins. For instance, the Rays swim almost entirely by the aid of the greatly expanded pectoral fins, which have an undulating motion very similar to that of the median fins of ordinary fishes. On the other hand, in the Flying Fishes (see "Flying Animals," Fig. 2) the pectoral fins are enormously elongated, so as to act as organs of spurious flight. Again, snake-like fishes, as the Eel, swim by lateral curvatures of the body, in the so-called serpentine manner.

The only other Vertebrate animals which breathe by means of gills, and can therefore be regarded as primitively aquatic, are the young, or larvæ, of the Amphibians (Frogs, &c.). The young Tadpole, as we all know, is an ugly, large-headed creature, swimming by means of lateral movements of its tail. This tail has a vertical fin-like expansion, differing, however, from the fins of fishes by the absence of the bony or cartilaginous rays found in the latter. We have already alluded to the remarkable metamorphosis undergone by the Tadpole, in the course of which the tail is lost, the gills are replaced by lungs, and the limbs developed. The adult Frog is an instance of an animal adapted to live partly on land and partly in the water, swimming powerfully in the latter element by the strokes of its long hind legs, of which the toes are fully webbed. The Tailed Amphibians, such as the Newts and Salamanders, are less specially modified than the Frogs, and may be completely aquatic. All the Newts and Salamanders, including the purely aquatic Giant Salamander of Japan, lose, however, their gills in the adult state; but these are permanently retained in the curious blind Proteus of the caverns of Carniola.

Among the true reptiles of the present day (all of which breathe by means of lungs during the whole of their existence) there are three groups among which aquatic forms occur. The first of these includes the Crocodiles and Alligators, which swim by means of their long tail and limbs. Although thoroughly at home in the water, where they spend a large portion of their time, the organization of these animals has not been so modified for the exigencies of an aquatic life as to depart to any great extent from the normal type. The same remark will apply with still more force to our Common Snake, which is an expert swimmer. In the Sea-Snakes, however, which pass the whole of their life in the tropical seas, the tail assumes a vertically compressed and paddle-like form, and is thus as efficient a propeller as the tail of a fish. These snakes always swim on the surface of the sea, but it is very doubtful if they can have given rise to the stories of the Sea-Serpent.

Among the Chelonians the Marine Turtles have been especially adapted for an aquatic life by the modification of their limbs into oar-like paddles; although it is quite clear that this structure is an acquired one. The Soft Turtles (Trionyces), of the rivers of the warmer regions of the globe, are almost equally good swimmers, although their feet, with the exception of being webbed, retain the ordinary type of structure. The Pond-Tortoise, now restricted to Southern Europe, although occurring in the superficial deposits of this country, is almost equally aquatic. Indeed all Tortoises (except perhaps the gigantic ones of the Galapagos and Mascarene Islands) are excellent swimmers, and thus afford a good instance of how some members of a group have gradually adapted themselves to an almost completely aquatic life.

If, however, the Turtles have been specially modified for an aquatic existence, still more markedly is this the case with the extinct Ichthyosaurs or Fish-Lizards (Fig. 5). Since the structure of these reptiles has been fully noticed in a separate article, we need only allude here to the peculiar pavement-like structure of the bones of

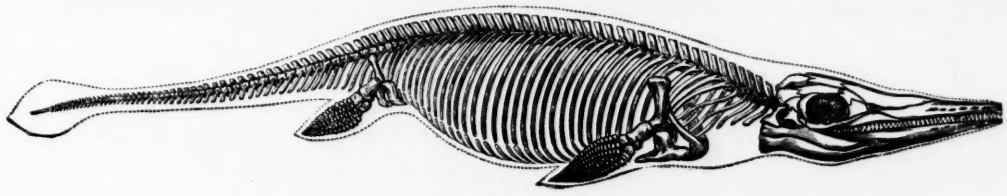


FIG. 5.—SKELETON OF AN ICHTHYOSAUR.

the paddles; this being the extreme modification which limbs have undergone for the purposes of an aquatic life. Since, as shown by the absence of gills and the indications of remnants of a horny covering to the body, there is abundant evidence that the Ichthyosaurs are descended from land animals, they occupy a position among Reptiles precisely analogous to that held among Mammals by the whales of the present epoch.

The long-necked Plesiosaurs, to which a special article in KNOWLEDGE has likewise been devoted, were reptiles equally well adapted for an aquatic existence, but in which the modification of the limbs into paddles had not been carried to the same degree as in the Ichthyosaurs. The evidence for the derivation of the Plesiosaurs from terrestrial reptiles is even fuller than in the case of the group last mentioned.

Before taking leave of the reptiles we have to allude to another totally different assemblage of extinct aquatic forms, which were much more closely allied to the existing Lizards, and many of which were of gigantic dimensions. These creatures are generally known as the Mosasaurs, and were first brought to notice during the last century, when a huge skull was obtained from the upper Cretaceous beds of Maastricht, on the Meuse; the Latin name of the group being taken from that river.

These Mosasaurs, of which a large number of kinds are now known, differ from the Ichthyosaurs and Plesiosaurs in that the joints of their backbone, instead of having both front and back surfaces either deeply cupped or nearly flat, had cup-and-ball articulations, the cup occupying the front surface. This type of structure is common to existing Crocodiles and Lizards; but whereas in the former the ribs articulate with the joints of the backbone by means of long transverse processes jutting out from them, in the latter the ribs articulate directly with the aforesaid joints. Now the Mosasaurs have the latter mode of articulation, and, since they agree with the modern Lizards in the structure of their skulls, as well as in many other points of their bony anatomy, there can be no hesitation in regarding them as a group descended from the ancestral Lizards which have taken to an aquatic mode of life.

The Mosasaurs are confined to the Cretaceous epoch, and thus lived side by side with the Ichthyosaurs for the greater part of their term of existence, although they attained their maximum development in the very highest Cretaceous beds when the Ichthyosaurs and Plesiosaurs seem to have disappeared. For a short time, then, these creatures appear to have been the only gigantic marine Vertebrates, filling up the gap left by the disappearance of the Ichthyosaurs, which had not yet been occupied by the Whales. They were of carnivorous habits, as shown by their formidable teeth, and, like all groups of Vertebrates which have taken to a marine life, far exceeded in dimensions any of their terrestrial cousins, the length of some of the species being as much as forty feet.

We come now to the Birds, several groups of which are exclusively composed of species specially adapted for an aquatic life. Swimming birds, as a rule, support themselves on the surface of the water, taking occasional dives of longer or shorter duration, and, therefore, have no need to make any especial arrangements for breathing. They swim by using their legs as oars, the feet being webbed, and the toes folding up as the foot is brought forward after one stroke to prepare for a second. As we shall see, however, some species aid their swimming with their wings. All birds that swim have relatively short legs, which are generally placed far back on the body, since this position gives the maximum power in propelling the animal through the water.

There are five chief groups of swimming birds, namely, the Ducks, Geese, and Swans (Anseres); the Pelicans, Cormorants, and Darters (Steganopodes); the Gulls and Petrels (Gaviæ); the Divers, Auks, and Grebes (Pygopodes); and the Penguins (Impennes). There are, however, a few members of other groups, such as the Dipper among the Passerines, and the Coot among the Rails, which are also expert divers and swimmers. The circumstance, however, that in neither of these instances is the foot fully webbed—that of the Dipper being like the foot of a Thrush, and that of a Coot (KNOWLEDGE, Oct., 1890, p. 236) only having web-like expansions on the sides of the toes—indicates that the habits of these birds are of comparatively recent acquisition, and have not induced any strongly-marked structural peculiarities.

The Anseres include by far the greater number of swimming birds, and the admirable adaptation of their form and structure to their mode of life is so well known as to require no further mention. The Pelicans and their allies differ from that group in that the web includes all the four toes of the foot (Fig. 6), instead of only the three front ones. In this group the Frigate Bird has a shorter leg than any bird of equal size. The Darters, or Snake-Birds, of which there are four species found in the warmer regions of the globe, and of which examples are generally to be seen in the Zoological Society's Gardens, are, however, those members of the group most interesting from our present point of view. These birds are found in fresh waters, and swim with the whole of the body submerged, so that only the head and upper part of the long and flexible neck are exposed. In this position they look not unlike snakes swimming on the water, when seen from a little distance. It does not appear that any use of the wings is made in swimming. The Gulls and Petrels, in which the hind toe of the foot is not included in the web, have longer legs than most swimming birds, and the legs themselves are placed nearer the middle of the body. Since these birds

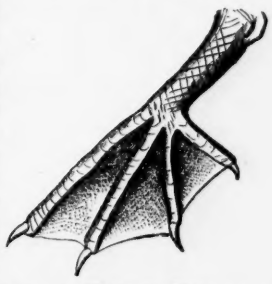


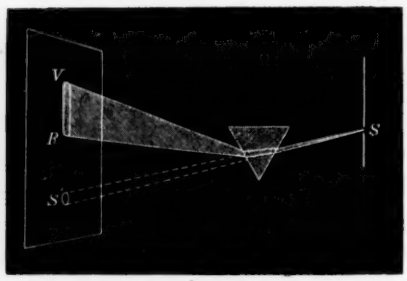
FIG. 6.—WEBBED FOOT OF A PELICAN.

depend mainly upon their powers of flight for obtaining their food, most of them only make use of the surface of the water, upon which they float placidly, as a resting-place. (*To be continued.*)

ON THE RHYMICAL GROUP OF HYDROGEN LINES VISIBLE IN MANY STELLAR SPECTRA.

By A. C. RANYARD.

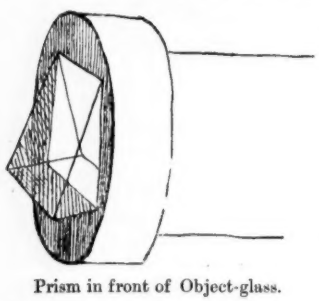
AS all readers of KNOWLEDGE know, a prism or wedge-shaped piece of glass breaks up a beam of white light into a series of coloured beams arranged fan-wise, the blue or violet rays being turned through the greatest angle. If such a prism be placed in front of a telescope, so as to send the refracted rays from a star down the axis of the telescope, an observer looking in at the eye end will see the image of the star spread out into a narrow line of light, blue at one end and red at the other. This narrow band or spectrum is not continuous, but is interrupted by small dark gaps, which are not very easy to see—but if the narrow spectral band of light is made to appear a little broader by looking at it with a cylindrical lens, the dark gaps become visible as lines across the spectrum, and appear similar to the dark lines across the Stellar spectra shown on the plate.



Prism breaking up a ray of white light from S. into a spectrum R.V.

The spectra reproduced in the plate were, however, photographed without a cylindrical lens. The narrow spectral streak of coloured light was turned so as to be at right angles to the direction of the star's diurnal motion, and by slowing the driving clock of the telescope the spectral streak was caused to sweep across the sensitive plate in a direction at right angles to its length, thus producing a trail or trace with dark lines across it, corresponding to the dark gaps in the spectral streak. The upper four Stellar spectra on the plate are from photographs kindly given me by the Brothers Henry, and the lower four are copied from photographs published by Prof. E. C. Pickering in connection with the spectroscopic work of the Draper memorial.

The method of observing Stellar spectra with a prism in front of the object-glass, and a cylindrical lens, was devised by Fraunhofer—nearly 80 years ago—in 1814. This remarkable man* turned a telescope with a prism in front of the object-glass to the stars, and noted some of the chief variations in their spectra. He found that the spectrum of Pollux closely resembled the spectrum of our Sun, while there were recognizable differences in the spectra of Capella, Betelgeuse and Procyon—they were all crossed by narrow dark lines, some of which he identified with solar lines. On the other hand, the spectra of Sirius and Castor were seen to be of a different type, and to be crossed by three massive dark bars, two in the blue and one in the green.



Prism in front of Object-glass.

After a lapse of 45 years Prof. Kirchhoff, of Heidelberg, found a key which enabled him partially to read the hieroglyphic language of the Fraunhofer lines, but much more remains still undeciphered until some Daniel shall arise who can interpret the story clearly written in letters of light upon the heavens. Kirchhoff passed a beam of sunlight across a space occupied by burning sodium vapour, and perceived with astonishment that the dark Fraunhofer line D, instead of being blotted out by the luminous rays of the same refrangibility as that given out by the flame, were rendered blacker and thicker by the superposition. He tried the same experiment, substituting the continuous spectrum derived from the light of a Drummond lamp for sunlight, but a dark line, corresponding in every respect to the solar D line, was seen to cross the spectrum. The inference was irresistible that these dark lines were produced by absorption of light corresponding in wave-length to the bright lines given out by the vapour, and that there must be an absorbing layer of sodium vapour about the Sun. This discovery was quickly followed up by the examination in the laboratory, by Prof. Kirchhoff, of the bright lines from other incandescent metallic vapours, and many of the bright lines from such vapours were identified with dark lines in the Solar spectrum. But in spite of all the work done by Prof. Kirchhoff and his assiduous pupil, Dr. Bunsen, and in spite of all the careful measuring and photographing of the lines in the spectra of terrestrial elements since their day, not one-fourth of the dark lines of the Solar spectrum have as yet been identified with lines in the spectra of terrestrial elements; and there are many mysterious discrepancies between the spectra of the elements, as observable under laboratory conditions, and the corresponding dark lines of the Solar spectrum. We are, therefore, very far from having read the riddle of the Solar spectrum, and we are much further from having learnt all that may be deciphered from the spectra of the stars.

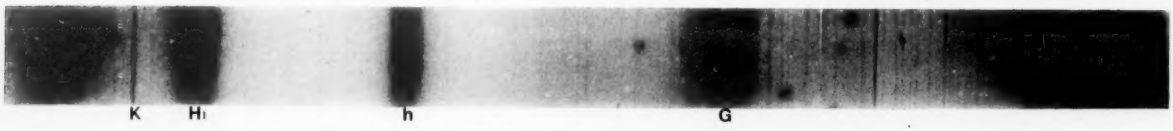
Soon after the publication of Kirchhoff's and Bunsen's results, Father Secchi set himself to the task of making a spectroscopic survey of the heavens. He examined the spectra of 4000 stars, and grouped them into four great classes, with the first of which we are at present more especially concerned. It contained Sirius and Vega, and more than half of the stars, which he examined. Their spectra are characterized by the great strength of the hydrogen lines, which are wide, hazy bands, much like the H and K of the Solar spectrum, though these lines in the Solar spectrum do not belong to hydrogen but to calcium, an element which is closely associated with hydrogen in the Solar prominences, but it is very different from it in atomic weight and chemical qualities.

* Fraunhofer greatly improved the achromatic telescope. He succeeded, after many experiments, in making the first large achromatic object-glass of high quality and finish. It was secured by the elder Strave for the Russian Government, and was long known as the "great Dorpat refractor," though it was only 9½ inches in diameter, and was of 14 feet focal length. He discovered nearly a thousand lines in the Solar Spectrum, and mapped 576 of them, naming the principal ones by the letters of the alphabet. He recognized the double D line in many Terrestrial Spectra, and noted the identity of its place with the solar D lines, though the true interpretation of the coincidence was not recognized for more than 40 years after he had laid such ample foundations for the deductions of modern spectrum analysis. After many ingenious experiments, he succeeded in making a diffraction grating, which showed him the lines in the normal spectrum.

XUM

SPECTRUM OF VEGA, *taken by the* BROTHERS HENRY *with a Crown Glass Prism of 22°.*

SPECTRUM OF VEGA, *taken by the* BROTHERS HENRY *with a Flint Glass Prism of 45°.*

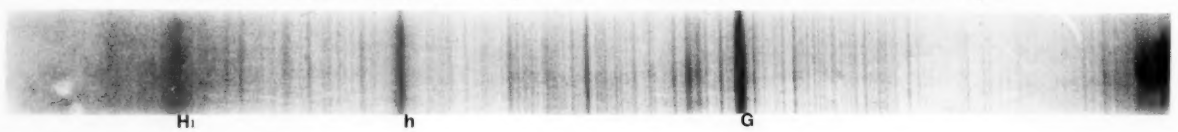


SPECTRUM OF ALTAIR, *taken by the* BROTHERS HENRY *with a Flint Glass Prism of 45°.*

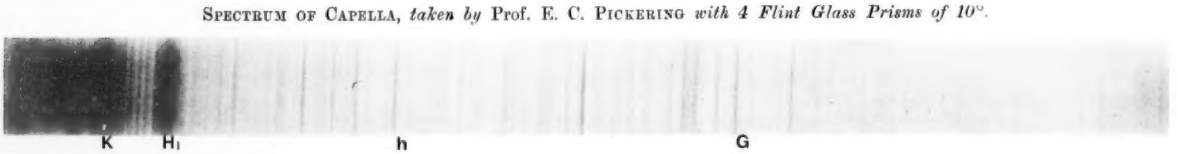
SPECTRUM OF ARCTURUS, *taken by the* BROTHERS HENRY *with a Flint Glass Prism of 45°.*

SPECTRUM OF α CANIS MAJORIS, *taken by* Prof. E. C. PICKERING *with 4 Flint Glass Prisms of 10°.*

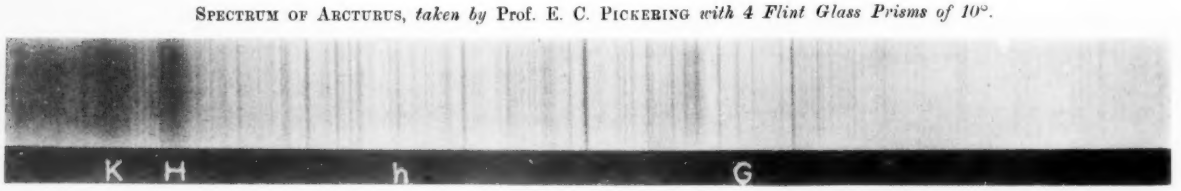
SPECTRUM OF α CANIS MINORIS, *taken by* Prof. E. C. PICKERING *with 4 Flint Glass Prisms of 10°.*



SPECTRUM OF CAPELLA, *taken by* Prof. E. C. PICKERING *with 4 Flint Glass Prisms of 10°.*



SPECTRUM OF ARCTURUS, *taken by* Prof. E. C. PICKERING *with 4 Flint Glass Prisms of 10°.*



The Automatic Engraving Company, Limited,
Strode Road, Willesden Green.

In the spectra of the stars of Secchi's first type the K line is generally faint, and it is sometimes entirely absent.

As early as 1863 Dr. Huggins attempted to photograph the spectrum of Vega, and succeeded in getting an impression of the spectrum, but without any of the lines. In 1872 Dr. Henry Draper, at Dobbs's Ferry, on the Hudson, succeeded in obtaining a photograph of the spectrum of Vega, showing, for the first time, four of its hydrogen lines.* The introduction of more sensitive dry plates in 1876 induced Dr. Huggins to turn again to the photography of Stellar spectra, and he soon succeeded in obtaining pictures showing many lines.

In a paper published in the *Philosophical Transactions* for 1880 on "The Photographic Spectra of Stars," he called attention to the arrangement of twelve strong lines in the spectrum of Vega. Remarking that the group possesses a distinctly symmetrical character, as the refrangibility increases the lines diminish in breadth, and the distance between any two adjacent lines is less; and he hazarded the suggestion that the lines must be "intimately connected with one another and present the spectrum of one substance."

Two of them may be seen in our reproduction, though they are very faint, and only just visible. There is a spot on the line ι, corresponding to a flaw on the negative of the Brothers Henry, which will enable the line ι to be easily identified, and the two faint lines will be seen beyond it, making in all sixteen‡ lines which can be counted on our reproduction.

All the lines of the group are of the same character, that is to say, they are broad and winged at the edges, and they become less intense and better defined in the order of their refrangibility. At the date of Dr. Huggins' paper in 1880, the lines of the hydrogen spectrum had only been photographed in the laboratory as far as δ, and their wave-lengths as given by Dr. H. W. Vogel corresponded within the limits of probable error with the wave-lengths of the typical lines measured by Dr. Huggins.

Vogel's numbers.	Dr. Huggins' numbers.
H λ 3968	λ 3968
α 3887	3887·5
β 3834	3834
γ 3795	3795
δ 3769	3767·5

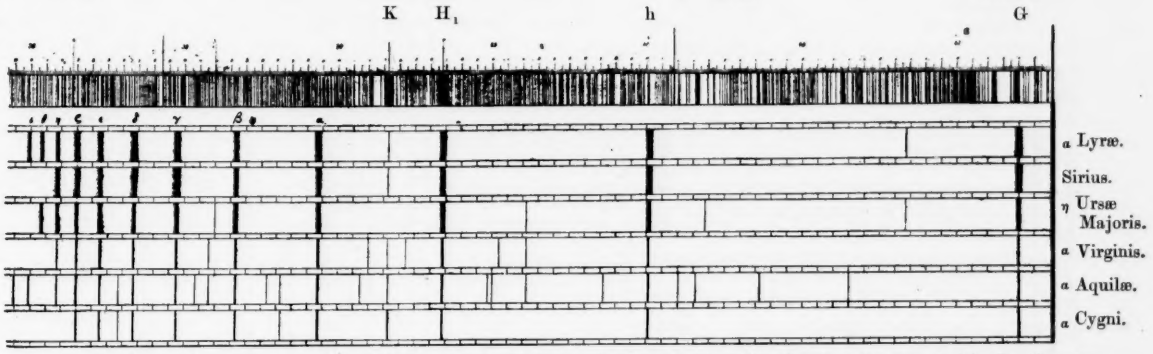


Diagram showing the relative intensity of the lines of the Hydrogen Spectrum in six Stellar Spectra, photographed by Dr. Huggins, copied from his paper on the Photographic Spectra of Stars in the *Phil. Trans.* for 1880.

In this paper Dr. Huggins designates the nine most refrangible of the twelve lines photographed by him by the Greek letters, α, β, γ, &c, ι being the last one seen on his photographs. He adds: "A circumstance of great importance is the entire absence of any lines in the spectrum beyond ι. The spectrum, which then becomes continuous, is strong, and extends beyond S in the ultra violet. In solar photographs, taken with the same apparatus, the lines in this region are well defined for some distance beyond S, and therefore this abrupt cessation of lines cannot be referred to an instrumental cause."

Dr. Huggins seems to have thought it strange that the group of lines was not continued further, and that if the lines belonged to a degrading series, and were due to a common physical cause, the group ought not to end abruptly at ι. His suspicion has been confirmed, for the photograph of the Brothers Henry, from which the uppermost spectrum on the plate has been copied, shows at least† three more lines on the more refrangible side of ι.

On the strength of this evidence, Mr. Johnstone Stoney wrote in a note published with Dr. Huggins' paper:—

"There can remain very little doubt that your typical lines are due to hydrogen. The evidence of their all being members of one physical system is made very plain when their positions are plotted down, for it then becomes conspicuous that they lie on, or very near a definite curve, which could not happen by chance.

"This question of whether they lie actually on, or only near a definite curve is, if I mistake not, of very great significance in the theory. If they lie *on* a curve obeying any exact mathematical law their connection must, I think, be attributed to their corresponding to the *consecutive* partial tones of some vibrating system (like those of an elastic rod or bell, for example). If, on the other hand, they lie near but not on the curve, this circumstance would support the hypothesis that the visible lines are members of harmonic series, most of the members of which are invisible, those only being seen whose positions chance nearly to fulfil a definite condition."

Mr. Johnstone Stoney converts Dr. Huggins' wave-lengths into wave-frequencies in air, and comes to the conclusion that assuming that the irregularities in the second differences cannot be referred to errors of observation, the positions of the lines *do not lie on but lie near to a definite curve.*

* The photographic record of Dr. Henry Draper, and his father, Dr. J. W. Draper, is very remarkable. The father, nearly half a century ago, obtained the first photograph of a human being, as well as the first photograph of the Solar spectrum, and the son obtained the first photograph of a nebula (the Orion nebula, which was photographed by him on the night of the 30th September, 1880), as well as the first photograph of a Stellar spectrum showing lines.

† Prof. Geo. E. Hale, with whom I have had the advantage of examining the photographs given me by the Brothers Henry, pointed out four lines beyond Dr. Huggins' line ι, and thought that he saw a suspicion of a fifth line.

‡ This includes the K line, which does not belong to the hydrogen spectrum, and the F line, which was not shown in Dr. Huggins' photograph.

He then points out that the wave-lengths of H and the line near G are connected harmonically, being exactly the 35th and 32nd harmonics of a vibration whose fundamental is $\frac{\tau}{72 \cdot 003}$ when τ is the time in which light travels a millimetre in air—a connection which is rather far fetched and unsatisfactory.

One of the most remarkable facts with regard to the vibrations of molecules which become visible to us as lines in the spectrum is that no simple harmonics are observed. Very good photographs of the solar spectrum have been taken, extending from above wave-length 3000 tenth-metres to below wave-length 8500 tenth-metres, but no repetitions of the lines and groups of lines are found to exist at positions in the spectrum corresponding to double the wave-length, or at two-thirds or any other simple multiple of the wave-length, as would probably be the case if a molecule was constituted like a bell or a tuning-fork, and gave out overtones corresponding to the chief vibrations with which it was pulsating.

Much interest naturally attaches to any relations that may be noted between the wave-lengths given out by an element, as they may teach us something with regard to the internal architecture of molecules. The strange groups of lines in the Solar spectrum and the numerous similar pairs and triplets indicate that there must be many such co-related lines, but the exact law of relationship needs to be worked out and traced back to its probable physical cause.

Some slight advances have been made in this direction. Prof. Hartley has called attention to a most remarkable relation connecting the lines in the series of triplets in the spectra of magnesium, zinc and cadmium. He corrected the wave-lengths for atmospheric refraction and then calculated the wave-frequency, and found that the differences of these frequencies for each triplet in any one series is a constant quantity within the limits of probable error of the observations used. That some such relation exists between the wave-lengths of the lines of the hydrogen spectrum was evident from the date of the publication of Dr. Huggins' paper.

In 1885 J. J. Balmer* gave a formula for connecting the wave-lengths of this group of lines of the hydrogen spectrum which approximately agreed with the positions of the lines as then known, and subsequent observations have shown that the formula is remarkably accurate. Balmer's formula is

$$\lambda = 3647{\cdot}20 \, \frac{m^2}{m^2 - 4}$$

where m takes in succession the values 3, 4, 5, &c. The value of λ, given by making m equal 3, corresponds to the wave-length of the C line; m = 4 gives the wave-length for the F line, and so on.

Prof. J. S. Ames, Assistant in Physics at John Hopkins University, has, in a very important paper published in the *Phil. Mag.* for July, 1890, given an account of his verification of this formula. Cornu † and Hasselberg ‡ had already examined the spectrum of hydrogen in the laboratory, under various conditions of electrical tension, and had succeeded in getting all the lines of the Stellar series as far as θ, as well as many other lines which are spoken of as belonging to the "secondary" spectrum of hydrogen. Prof. Ames repeated their experiments, taking every precaution in the measurement of the positions of the lines, and his places agree remarkably well with Balmer's formula when they are corrected so as to correspond with the refractive indexes in vacuo. Prof. Ames remarks that he was entirely unable to obtain the Stellar series of lines by itself, although he says "I am confident my hydrogen was pure and I varied the tubes, the current, the vacuum, and the exposure. I also introduced large condensers without any noticeable change." We therefore do not seem at present to be able to imitate in the laboratory the conditions under which hydrogen exists in stars having the first type of spectra, and the same remark applies to nearly all the spectra of elements recognizable in the Solar spectrum.

The accuracy of Prof. Ames' measures are confirmed by their agreement with Prof. George Hale's measures of the positions of the hydrogen lines in the Solar Prominences, which are given below.§ There is some slight doubt

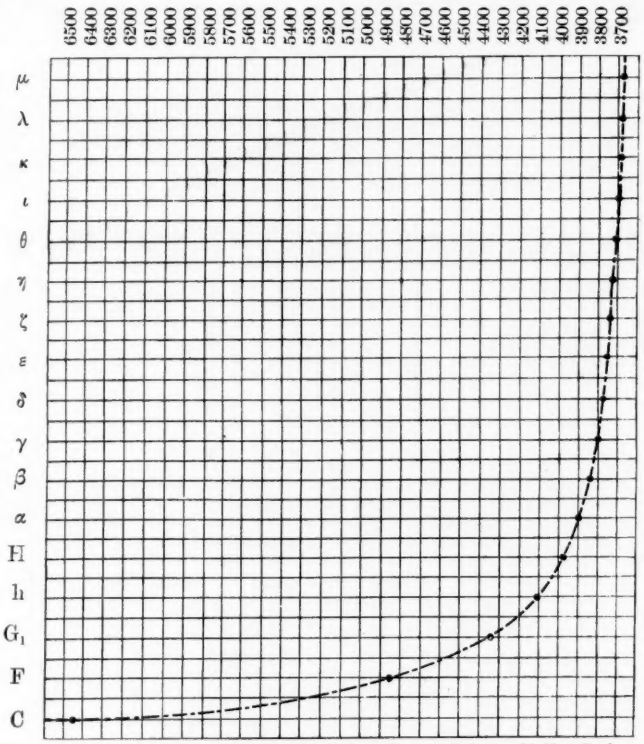


Diagram illustrating the relation of the Wave-Lengths of the Stellar Series of Lines in the Spectrum of Hydrogen.

§ Positions of lines in the hydrogen spectrum as measured by

	Ames.	Hasselberg.	Cornu.	Huggins.	Hale.
C	6563·04				
F	4861·49	4860·60			
G_1	4340·66	4340·06	4339·5		
h	4101·85	4101·18	4101·0	4101·0	
H	3970·25		3968·9	3968·9	3970·11
α	3889·15		3887·8	3887·5	3889·14
β	3835·6		3834·5	3834·0	3835·54
γ	3798·0		3796·9	3795·0	3798·1
δ	3770·7		3769·4	3767·5	3770·8
	3750·15		3749·3	3745·0	
ζ	3734·15		3733·6	3730·0	
η	3721·8		3720·6	3717·5	
θ	3711·9		3710·7	3707·5	
ι				3699·0	

* *Wied. Ann.* xxv. 1855.
† *Jour. de Phys.* [10] v. 1886.
‡ *Mém. de l'Acad. Imp. St. Pétersb.*, xxx. p. 7 (1882), xxxi. p. 14. *Bull. de l'Acad. Imp. St. Pétersb.* xi. p. 203 (1884).

about the proper correction for atmospheric refraction, but using the numbers adopted by Prof. Ames, we have

	Places calculated $=3647{\cdot}20\ \frac{m^2}{m^2-4}$.	Places observed by Ames, corrected for atmospheric refraction.
C	6564·96	6564·97
F	4862·93	4862·93
G_1	4341·90	4342·00
h	4103·10	4103·11
H	3971·4	3971·40
α	3890·3	3890·3
β	3836·7	3836·8
γ	3799·2	3799·2
δ	3771·9	3771·9
ε	3751·4	3751·3
ζ	3735·6	3735·3
η	3723·2	3722·8
ϑ	3713·2	3712·9

The positions of the next three lines, ι, κ, and λ, calculated from Balmer's formula, are 3705·1, 3698·5, and 3692·9, which agrees very satisfactorily with the positions of the lines shown on the photograph of the spectrum of Vega given me by the Brothers Henry.

We may, therefore, feel some confidence that Balmer's formula corresponds to a physical fact, and that one series of tremors with which the hydrogen molecule vibrates when it is disturbed, are related so that the length of the waves produced, when plotted as in the diagram, fall upon a curve having an asymptote at wave-length 3647·20.

If m be made equal to 1 in the formula, we get an infinite value for λ; which indicates that there ought to be one line of the series forming the limit of the spectrum at the extreme red end. When m is made equal to 1, we get $\lambda = -1215{\cdot}4$. It would be interesting to determine whether this negative value of the wave-length may be interpreted as meaning a wave of opposite phase. If so, we should expect to find a line of the series at wave-length 1215·4, a region of the spectrum which has not yet been explored.

Notices of Books.

Popular Astronomy: A series of Lectures delivered at Ipswich by Sir George Biddell Airy, K.C.B., Astronomer Royal, revised by H. H. Turner, M.A., B.Sc., Chief Assistant Royal Observatory, Greenwich. These lectures of Sir G. B. Airy are a model of clear and simple exposition. They were delivered more than forty years ago (in March, 1847) to the members of the Ipswich Museum and their friends, and were, as Sir G. B. Airy explained at the time, intended to be understood by working men. That he succeeded in making the somewhat difficult and dry subjects that he dealt with interesting is attested by the fact that the book has passed through six editions, and that now a seventh is called for. The instruments used in observatories have so changed since the date when the lectures were delivered that Mr. Turner has had a difficult task in making the necessary alterations in the text without suggesting anachronisms or greatly altering the form in which the lectures were delivered, but he has done his work with great discretion, and has added some interesting notes. Amongst the many "Popular Astronomies" which have been written it would still be difficult to select a better book to give to young people whose interest in Astronomy is dawning.

Pictorial Astronomy. By G. F. CHAMBERS, F.R.A.S.—Mr. Chambers has barely finished working upon his enlarged edition of the "Descriptive Astronomy," when he gives us another entirely new volume, intended for beginners in Astronomy. It is profusely illustrated, and contains a great deal of valuable information, with some useful tables and practical suggestions for those who meditate setting up a small observatory, but the drawings of observatories and instruments are mostly of very old-fashioned type. In fact all the illustrations are antiquated, and we recognize most of them as old friends, which have done yeoman's service in the teaching of Astronomy. But the strength of Mr. Chambers' books never lays in their illustrations.

Outlines of Field Geology. By Sir ARCHIBALD GEIKIE, F.R.S. Fourth edition. (Macmillan.)—Among the many works of this distinguished author, few are more welcome than this new and much enlarged edition of his well-known "Field Geology." Two lectures upon geological maps and instruments of surveying, delivered in 1876, and published in pamphlet form in the same year, were the source from which this book took its origin. In 1879 a second edition appeared in a more permanent shape, so much enlarged and re-cast as to constitute a new book, of which the present edition is a still further improved form. As the author says in the preface, his aim has been to write for the large body of readers who, though possessing some general acquaintance with Geology, find themselves helpless when they try to interpret the facts which they meet with in the field. Sir Archibald acts as a most interesting interpreter to them as they examine the rocks exposed in quarries, ravines, or sea-shores; and there can be no doubt that anyone who follows his instructions, and observes according to his rules, will find himself in a fair way to understanding the geological structure and history of the particular district in which he is interested. It is needless to say that the writing is clear and concise throughout. We have only space to refer to the more interesting parts of the book, and to those in which some of the most recent results of geological science are introduced. Beginners, who are usually rather hazy in their ideas of the different rocks composing the earth's surface, should carefully study the excellent chapter on the determination of rocks, if they wish to be saved from endless mistakes. The chapters on the tracing of boundary lines, and the unravelling of geological structure, contain many useful hints, the result of the author's wide experience in geological surveying. One of the best chapters in the book is that in which the igneous rocks, and their modes of occurrence, are described. In the chapter on schistose rocks and mineral veins, we find references to some very interesting recent discoveries about the sheering and crushing of rocks. The schistose rocks have been subjected to enormous pressure, and extensive deformation has taken place; thus, in some conglomerates the pebbles have been crushed and flattened, and even pulled out of shape, whilst their sandy or gravelly matrix has been converted into a schist. A crystallization of the crushed material has taken place along the planes of sheering or cleavage, thus causing foliation. Igneous rocks, too, have suffered in the same way. Dykes of basic rocks, such as basalt, have been changed into fissile hornblende schists! In chapter X., the wonderful thrust-planes in the north-west of Scotland are referred to. Some of the rocks of that district have been pushed for many miles over others.

XUM

Manual of Assaying. By WALTER LEE BROWN, B.Sc.; Revised, Corrected, and considerably Enlarged by A. B. GRIFFITHS, Ph.D., F.R.S. (London: W. Heinemann. 1890.) Mr. Brown's manual, of which this work is a revised edition, is well known to practical assayers, though its reputation has probably been greater in the United States than in this country. Dr. Griffiths has improved the work in several respects, and has added an important chapter on Fuel. We could have wished that more use had been made of the great work by Dr. Percy, certainly a higher authority than Mitchell's manual, to which the author frequently refers; and perhaps some of the illustrations might with advantage have been replaced by new ones. One drawback with regard to the drawings representing instruments and apparatus is that they are not on anything like a uniform scale—no one could form a correct idea of the relative sizes of the things themselves from the woodcuts: *e.g.*, the hammer and anvil on page 69, and the cupel on page 63. The different processes employed by the assayer are carefully and clearly described, and the various possible causes of failure in obtaining trustworthy results are, in most cases, sufficiently indicated. Part I. deals with apparatus and re-agents, and is divided into three chapters, in which descriptions are given of the implements used for pulverizing, sampling, &c., scales and balances, weights, furnace tools; also wet and dry re-agents for assaying. Then follow descriptions of certain processes, such as the testing of lithage for silver, the testing of lead for silver, and the determination of the reducing and oxidizing of certain agents. These descriptions, which are thoroughly practical, are largely helped by numerous illustrations of apparatus and instruments. Perhaps the most valuable feature of the book is the way in which the numerical examples of assaying are worked out in several places in the body of the treatise itself and in the appendix. These will doubtless be appreciated by such students as may be endeavouring to prepare themselves by self-tuition for future practical work as assayers. We quote the following passage as an example to show the practical nature of the book: "Absolutely accurate assays of gold and silver bullion require care, skill, and first-class apparatus. The skill may soon be acquired by practice, but the apparatus must not only be of the best quality, but must be kept in the most perfect state of adjustment. It is not enough to purchase chemicals which are marked 'pure,' or a balance supposed to be accurate: the chemicals must be tested, and the accuracy and adjustment of the balance and weights verified, before correct results can be obtained." The appendix concludes with lists of the principal gold, silver, copper, and lead minerals, a list of useful books connected with the subject, a plan of a laboratory, outfit, tables of weights and assay ton equivalents.

Coal, and what we get from it: a Romance of Science. By RAPHAEL MENDOLA, F.R.S. This very instructive little treatise is one of the "Romance of Science Series," published by the S.P.C.K., and the name of its author is sufficient guarantee for thoroughness and accuracy. Though some readers might perhaps be somewhat repelled at first by the long names given to carbon compounds, yet we think this prejudice will be overcome as they peruse its pages, and give place to a keen sense of delight as they follow the marvellous transformations so ably described by the author. The earlier chapters of the book contain a clear and interesting account of the origin of Coal, and of the energy stored up in it, illustrative of George Stephenson's celebrated statement about "bottled-up sunshine." This is followed by a sketch of the history of coal gas, together with an account of its manufacture as at present carried on. The author next takes up the subject of the commercial importance of the liquid and solid products resulting from the distillation of coal, viz.—the "ammoniacal liquor," the coke, and the tar. The second half of the book is, in fact, occupied with the history and description of the marvellous range of substances obtained, directly or indirectly, from coal tar. In the early days of gas manufacture, this black unsavoury residue was, in every sense, a "waste product," and the manufacturer was only too glad to get rid of it as best he could. Now it is made to furnish not only an almost endless variety of brilliant colours, but delicious essences and delicate perfumes, while immense fortunes have been realized by the fortunate discoveries of the processes by which such results have been obtained.

In 1828, Faraday discovered his "Bicarburet of Hydrogen" in the oil produced by the condensation of the so-called "oil-gas." In 1834, the same hydro-carbon was obtained by Mitscherlick by heating benzoic acid with lime, and since then it has been known in this country as benzol or benzene. In 1845, Hofman proved the existence of benzine in the light oils from coal tar, and in 1858, Perkin took out his first patent for a coal-tar colour under the name of "mauve." For the wonderful development of this branch of chemistry, and for an account of its extension to medicine, sanitary science, photography, and the arts, we must refer the reader to the book itself, which will well repay careful reading, and put him in possession of the latest processes and discoveries.

Prof. MAX WOLF, of Heidelburg, has obtained some interesting photographs of the Milky Way, in the neighbourhood of α Cygnus, which we hope to reproduce in the October number.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

ON THE COMPARISON OF PHOTOGRAPHS OF THE MILKY WAY.

To the Editor of KNOWLEDGE.

DEAR SIR,—In the letter on the above subject which appears in the May number of KNOWLEDGE, Mr. Barnard raises a question of great importance. The words used are, "I have no hesitation in attributing the difference between these pictures entirely to the development of the negative. As I have taken occassion to remark elsewhere, the utmost care must be exercised in the development of Milky Way pictures to bring out the cloud-forms clearly and strongly." This is a point that forced itself upon my notice as soon as I began taking photographs of the Milky Way, for the details in these pictures are often as delicate as a thin fog on the plate, and the slightest over-developing may suffice to produce such marks, which it is almost impossible to distinguish from features of the Milky Way. Indeed, I only know of one method of making sure which parts of the negative show faint Milky Way features and which are fog, and that is to multiply the pictures and compare them carefully. Now, my photograph of the Milky Way about α 17h. 58m. and δ 30°, which you reproduced in KNOWLEDGE for March last, is from one of eight negatives of this object which I have taken, and it is not the best so far as the nebulous part is concerned, but they all agree in

supporting the picture in March number of KNOWLEDGE as to the *relative brightness of the several parts* of the nebulous light. I think, therefore, there can be no doubt that my picture is right and Mr. Barnard's suffers from over-development. I have adopted the same method of making sure of the features in other parts of the Milky Way, and I am sure it is necessary where exceedingly delicate details have to be shown. When my photograph to which Mr. Barnard refers was taken, your reproduction of his of the same object was before me, and I saw the differences, which I was then disposed to attribute to the great advantage Mount Hamilton has in elevation, but Prof. Pickering's opinion of the advantage of a mountain station—that it only enables us to photograph stars $\frac{1}{3}$ of a magnitude lower—seems to make my supposition untenable, and to leave no alternative but that the difference is due to development, and I think over-development of the Mount Hamilton picture. Seed's plates are undoubtedly very good—I have used some of them, and I think highly of them—but they are not so sensitive as the Ilford plates, which I used for the pictures in question.

My experience leads me to the conviction that where extremely delicate details have to be caught, such as those in the Nubecula Major, the nebula about Eta Argus, and others, what is required is length of exposure rather than strong development. I have repeatedly tried the two methods, *i.e.*, long exposure and strong development, on the same object, and have no hesitation in saying that for delicate nebulous details the latter is to be decidedly avoided. Yours very truly,

Sydney Observatory, H. C. RUSSELL.
July 6th, 1891.

[A close examination of Mr. Barnard's picture of the Sagittarius region referred to by Mr. Russell has convinced me that the nebulosity shown upon it really corresponds to areas of luminosity on the heavens, and is not a mere photographic fogging due to over-rapid development. There is an intimate connection between the dark areas on Mr. Barnard's photograph and the disposition of the stars which could not be due to chance, and the bright structures are altogether different in form from the patches in which fog shows itself on an over-developed picture. From my experience in reproducing pictures of nebulæ, I can fully confirm Mr. Barnard's statement that the density of the nebulosity and fainter cloud forms is very dependent on suitable development. It is to be regretted that circumstances have prevented Mr. Barnard from taking more photographs of this extraordinary region of the Milky Way. Mr. Russell has recently sent me some most interesting photographs of the η Argus Nebulæ and the κ Crucis cluster, which I hope shortly to reproduce in KNOWLEDGE. —A. C. RANYARD.]

THE OBSERVATION OF RED STARS.

To the Editor of KNOWLEDGE.

DEAR SIR,—I have been considerably interested by a perusal of Miss Clerke's article, with the above heading, in the August number of KNOWLEDGE. With much of what is there stated I entirely agree; though, with all possible deference to the gifted authoress, I venture to dissent from her conclusions on one very material point, and that is—can the alleged variation of colour in certain stars be accepted as a demonstrated *fact*? A long experience of my own in observing star colours, as well as that resulting from the superintendence of such work by other observers, has made me extremely sceptical on this point; and I should require stronger evidence than we now possess to admit that such a conclusion was established. Casual star-gazers have no idea of the practical difficulties that beset this subject. Eyes differ so widely in their colour perceptions, that it is really not safe to accept the uncorroborated testimony of any one observer until it has been ascertained that his colour faculty is fairly normal. Neither can the differences arising from various kinds and apertures of telescopes be safely ignored: reflectors almost invariably give deeper tints than refractors, whilst any great difference in aperture has its corresponding effect. Then there is the atmospheric influence to be added to the account, and experienced observers know that this is a potent factor. The altitude of the star, the degree of darkness of the sky background, humidity and clearness of the air, etc.—if apparently trivial each by itself—will, combined, exercise some perceptible effect on the resulting colour. Therefore, I contend that the most satisfactory method of eliminating these errors—personal, instrumental, and atmospheric—is to take the *mean* of a large number of independent contemporaneous estimates by different observers, and accept that as the nearest probable approach to the true result. I would like to make a few remarks on the objects cited as examples of variation in colour:—

Espin-Birmingham, 352 (Schj. 148). The discrepancies in its assigned tint of redness are quite within the usual range of errors of observation, the large difference in the apertures of the telescopes used being alone sufficient to account for much of the discordance. The evidence for variation in magnitude does not seem very strong; indeed, it might reasonably be inferred that Birmingham's solitary observation of "no colour" belonged to some other star.

Es-Birm. 221 (Schj. 90). I think there is quite a possibility that these irreconcilable estimates relate to two different stars. According to the B.A. Catalogue (which formed the basis of my working list in 1877-8), there are two $6\frac{1}{2}$ mag. stars close together near this place —B.A.C. 2365 and 2369, otherwise 44 and 45 Camelopardi. Now the former of these agrees so closely with the position given for Es-Birm. 221, that it seems as if they must be synonymous; this was the object I observed as "$6\frac{1}{2}$ mag., orange red," with a 5 inch refractor. For the other one (32s. following and 13′ north), I could find no star larger than 8 mag. in its place, and as no colour was mentioned, it was presumably white. Possibly one or both of these stars may be variable in magnitude.

Birm. 118 (Schj. 63). This I noted in 1885, with $11\frac{1}{4}$ inch reflector, as "yellowish white." Perhaps there is some reason to doubt its identity, judging from the foot-note to the Dunsink observations, which suggests that the estimate probably belonged to another star closely preceding.

Es-Birm. 544 (Schj. 214). It does look as if there was some reason to suspect variation here, in magnitude if not in colour. But a more extended series of observations are required before the latter assumption can be legitimately entertained, as there is a gap of fourteen years between Espin's observation and the last recorded one preceding.

r Velorum does indeed appear to offer promising ground for further investigation, but, in the meantime, it would be wise to suspend judgment.

If suspected colour variables have been apparently neglected, it is because the evidence for variation is so slender that it finds but little acceptance in the astronomical world. We *must* be sure of the facts before proceeding to draw deductions from them—and the facts are scarcely established, as yet. In saying this, I am equally desirous of further investigation in the fascinating field of stellar chromatics, and think, with Miss Clerke, that the spectroscope is the most promising instrument to deal with the

problem. But it is, however, *possible* that two stars of similar colour might have different spectra, because there are several pairs of complementary tints which, when united, produce white light.

W. S. Franks.

SOME PRACTICAL APPLICATIONS OF ELECTRICITY.

By J. J. Stewart.

(*Continued from page* 33.)

II.—Secondary Batteries.

When a current of Electricity passes from a copper plate immersed in a solution of a copper salt, such as copper sulphate, to another plate opposite to it in the same solution, say one made of platinum, copper is deposited on the platinum plate owing to the decomposition of the solution, the amount of copper thus set free being proportional to the strength of the current which passes. Faraday was the first to prove this, and called the apparatus, consisting of the trough of solution and the plates dipping into it, a *voltameter*, because it served as a means of measuring the strength of currents. [I may say, in passing, that a voltameter on just the same principle as this is used by Edison to act as a current meter to indicate the quantity of Electricity sent from his electric light mains to any single house.] If an electric current is made to traverse a cell consisting of two plates of platinum placed opposite each other in acidulated water, the water is continuously decomposed into its constituent elements during the passage of the current, provided this current is above a certain strength; but whilst this operation goes on a remarkable phenomenon is noticed, the current which commences with a given strength becomes weaker and weaker, and if a galvanometer is placed in the circuit in order that the behaviour of the current may be observed, what is seen to happen is this—the galvanometer needle, when the current through the cell is first started, swings off vigorously and comes to rest at a certain angle of deflection, indicating the strength of the current, but, on further watching, it is seen to be creeping back; the deflection is gradually decreasing towards zero. On looking at the platinum plates in the water, bubbles are seen to be formed upon their surfaces, which rise in two streams to the top of the liquid; these consist of the constituent gases of the water, hydrogen being set free at the plate where the current leaves the voltameter cell—or the *cathode*, as Faraday calls it—and oxygen at the plate where the current enters, or the *anode*; some of these gas bubbles, however, are seen to cling to the plates instead of rising up through the water. On looking more closely, it is seen that the streams of rising bubbles are decreasing simultaneously with the falling off of the galvanometer deflection, and after a time this deflection settles down to a fairly constant value, which may be considerably less than that at which it started. This is an example of *polarization*; the falling off of the current has been found to be due to an opposing electro-motive force which arises owing to the deposit of a layer of oxygen on one of the platinum plates, and a layer of hydrogen on the other, which layers extend into the substance of the platinum as well as over the outer face. The tendency which these liberated gases have to combine again to form water gives rise to the opposing electro-motive force which acts against that driving the current through the cell, and the final current produced is due to the resultant of these two opposite electro-motive forces. If the two platinum plates which have thus been exposed to a current for a time be taken out of the cell and placed opposite each other in a similar trough of acidulated water, and then joined by a wire through a galvanometer, it will be observed that they now send a current themselves, but in an *opposite* direction to that which passed between them originally from the external source. They act as a battery which becomes weaker and weaker until the layers of gas sticking to their faces disappear, the oxygen and hydrogen having united again to form water. Sir William Grove discovered that if two plates of platinum were fixed, one in a closed vessel of oxygen, and the other in one containing hydrogen—the gases being obtained from any source—a current passed between the two plates when they were joined through a conductor; they behaved like the plates treated as above, and constituted a "gas battery." Such an arrangement as that described, consisting of platinum plates previously prepared by having a current passed between them whilst they dip in water, is an example of one of the earliest forms of secondary battery.

Such an arrangement, however, cannot be applied to any practical purpose, the duration of the second reversed current being quite transitory. Gaston Planté was the first experimenter to make secondary batteries on a large scale. He found lead to be the most suitable metal to use for this purpose. When two plates of lead are immersed in dilute sulphuric acid, and a current made to pass between them, one plate becomes oxidized, rusted so to speak, owing to the combination with it of the oxygen set free from the water containing the acid. Now when the current is sent in the opposite direction through the decomposing solution, entering at the plate where it formerly left, the plate which was previously oxidized becomes deprived of its oxygen, and the other plate is oxidized instead. Planté made use of this process to "form" the plates to be afterwards used in his secondary batteries; currents were sent first in one direction and then in the other through the plates and dilute acid. In course of time one of the plates, that which last formed the cathode, or the plate where the current left the liquid, became, through repeated gain and loss of oxygen, of porous structure, exposing a large surface to the solution, whilst the other became very strongly oxidized, and covered to a considerable depth with lead peroxide. When these two plates thus prepared are placed in dilute sulphuric acid, and joined by a wire, a current of Electricity passes along the wire in the opposite direction to that which was last sent through the preparing plates from an external source. This apparatus now forms a secondary battery or accumulator, which is capable of furnishing a continuous flow of Electricity for prolonged periods. The name "accumulator" is applied to such a battery from its accumulating, as it were, the chemical energy stored up in it when the charging current was passed, and afterwards giving it out in the form of electric energy. The battery thus laboriously made by Planté, which takes months to form by repeated current reversals, does not differ in any important particular from those in use at the present day, but now they are made in a much shorter time, by starting with lead oxide (or red lead) already made for one plate, instead of making this by a long-continued series of alternately reversed currents, as in Planté's original process. The plates made by the Electric Power Storage Company consist of gridiron-like arrangements, with the gaps of the framework, which is of lead, filled up with little blocks of minium or red lead. This has the advantage of offering a large surface to the action of the liquid. Formerly both of the plates of each cell had the plugs which filled up the

interstices of the grid made of a paste of red lead ($Pb_3 O_4$), but since then litharge (Pb O), a lower oxide, has been used for those of the negative plate, and the red lead put only in that plate which was intended to be used afterwards as the positive pole of the battery. Moreover, in recent methods the two plates are "formed" apart, each by itself, and the time the current is sent through the negative plate is much longer than that applied to the positive.

The old form of secondary battery, that used by Planté and consisting of two opposed plates, one made of spongy metallic lead and the other of lead oxide, may be taken as the typical form of secondary battery, and the essential process which goes on is the transference of oxygen from the oxide of lead plate to the one consisting of metallic lead. Lead sulphate is formed as well as the peroxide of lead, and a considerable portion of the acid in the cell is used up in producing this. The current owes its origin to the presence of two substances, lead and oxygen, which have a chemical affinity for each other, and thus the action does not differ in its nature from that of an ordinary galvanic cell.

Secondary batteries require periodical renewal, as during their action the coating of lead peroxide becomes deoxidized, and both plates approach to the same composition. This re-forming is readily done by sending for some hours a current from some exterior source, such as a dynamo machine, into the cells in a direction the reverse of that of the current which is produced by the battery itself. After this the battery is restored to its original state, and is capable of furnishing a remarkably steady and unvarying current for many hours in succession.

Accumulators are a valuable source of Electricity where a considerable current is needed for lighting purposes, and are also useful as an alternative source where the dynamo is used, as, in the case of a temporary break-down of the dynamo, the secondary batteries can be switched on to the circuit. For such purposes as the electric propulsion of small vessels at sea, they seem to be the most economical means, and are beginning to be extensively used for the propulsion of electric launches and tramway cars; the secondary batteries being used to furnish the current necessary to drive the electric motor.

Dr. Frankland lit up his house years ago with success by means of secondary batteries, and when he was absent for some months and the light not used, he found on his return the batteries still in good condition, and the light ready to be turned on at once.

A DOUBLE PLANET.

By J. E. Gore, F.R.A.S.

DOUBLE stars are numerous in the heavens, and double nebulæ are not uncommon. Even double comets have been recorded, as in the case of Biela's comet, and the faint companions which have been observed in close attendance upon some of the large comets of recent years. The duplicity of one of the satellites of Jupiter has even been "suspected," but, as far as I know, the suspicion has not been confirmed. Although many of the planets of the Solar System are attended by satellites, they are usually considered as single bodies. We may however, perhaps, make an exception of this rule in the case of the Earth and Moon, which have been termed "a double planet" for the following reasons:—

The Moon's volume compared with that of its primary is greater than that of any other satellite of the Solar System. The volume is about $\frac{1}{49}$ of the Earth's volume, and its mass about $\frac{1}{81}$ of that of the Earth. The volumes of the satellites of the other planets bear a much smaller ratio to the volume of the primary. We need not consider the satellites of Mars, which are very minute bodies, and quite insignificant in size compared with their primary. The largest of the satellites of Jupiter has a volume only $\frac{1}{16000}$ of that of the "giant planet." The largest of Saturn's satellites, Titan, has probably not more than $\frac{1}{10000}$ of the volume of Saturn. The exact size of the satellites of Uranus is unknown, but judging from their faintness, we may conclude that their volume is small compared with that of their primary. Even the satellite of Neptune, supposed to be the largest satellite of the Solar System, is probably small compared with the planet. Taking its diameter at 4000 miles, and that of Neptune at 36,000 miles, the volume of the satellite will be only $\frac{1}{729}$ of Neptune's volume.

We see, therefore, that the Moon is *comparatively* a very large satellite. It is, of course, *absolutely* smaller than the largest satellite of Jupiter, Saturn's satellite, Titan, or the satellite of Neptune; but compared with the Earth, which is a small planet (in comparison with Jupiter, Saturn, Uranus or Neptune), it must be considered as really an enormous satellite, and in *relative* size deserving to rank rather as a small planet accompanying the Earth in its annual journey round the Sun, than as a satellite revolving round it.

Seen from Venus, the Earth and Moon will appear more like a "double planet" than a planet with an attendant satellite. From a consideration of the brightness of Venus as seen from the Earth, we may form an estimate of the probable brightness of the Earth and Moon as viewed from Venus. To do this it will, of course, be necessary to make some assumptions. We should require, in the first place, to know the "albedo," or reflecting power, of the Earth's surface.

To determine this accurately would not be an easy matter, but if we assume that it has the same "albedo" as the Moon, we may not, perhaps, be very far from the truth. Now Zöllner found the "albedo" of Venus to be represented by the fraction 0·50, or about three times the Moon's "albedo" (0·1736).

Venus, when at her greatest brilliancy, and approaching inferior conjunction, is distant from the Earth about 39 millions of miles, and has then about one-fourth of the area of her disc illuminated by sunlight. The Earth when in "opposition," and therefore at its brightest as seen from Venus, is distant from the planet about 26 millions of miles. Hence we have the relative distances in the ratio of 39 to 26 or as 3 to 2.

If, to simplify the calculation, we assume the diameter of the Earth and Venus as equal, the apparent areas of their discs will be as 3^2 to 2^2 or as 9 to 4. That is, the area of the Earth's disc when in "opposition," as seen from Venus, will be about $2\frac{1}{4}$ times the area of Venus's disc when at her brightest as seen from the Earth. Now as the Earth shows a *full* face to Venus when at its brightest, and Venus only one-fourth of a fully illuminated disc when at its brightest to us, we should have the Earth brighter than Venus in the proportion of 36 to 4, or as 9 to 1, *if* the distances of both planets from the Sun and their "albedos" were the same. But as their distances from the Sun are in the ratio of 93 to 67, Venus will be more brilliantly illuminated in the ratio of 93^2 to 67^2, or about as 19 to 10, and as its "albedo," as assumed above, is three times greater, we have the brightness of Venus's surface greater than that of the Earth's surface in the ratio of 57 to 10. Hence, finally, we have the

brightness of the Earth, when in "opposition," as seen from Venus, brighter than Venus at its greatest brilliancy as seen from the Earth in the ratio of 90 to 57.

Taking the diameters of the Earth and Moon as 7912 miles and 2163 miles respectively, the areas of their apparent discs would be in the ratio of 13·38 to 1. Hence, with the same "albedo," the Earth and Moon, as seen from Venus, would differ in brightness by 2·81 stellar magnitudes.

Now Plummer found that Venus at its greatest brilliancy is nine times brighter than Sirius. The Earth, therefore, as seen from Venus, would appear $(\frac{90}{57} \times \frac{9}{7})$ 14·21 times or 2·88 stellar magnitudes brighter than Sirius. The Earth and Moon would therefore shine as two stars, one about half as bright again as Venus at her brightest, and the other about equal to Sirius, and separated, when the Moon is in "quadrature," by about 31 minutes of arc, forming a superb "naked eye double star," perhaps the finest sight in the planetary system. They would present the appearance of a "double planet," in striking contrast with the faintness of the other satellites of the Solar System. The Earth would show a disc of about 62″ in diameter, and the Moon one of about 17″, and the markings on both might be well seen with a good telescope.

Seen from Mars, the Moon would also be visible as a small attendant planet to the Earth, but varying considerably in brilliancy owing to its phases.

The Moon's title to rank as a planet rather than a satellite is strengthened by the fact that her path in space is, like the planetary orbits, always concave to the Sun. Professor Young says in his "General Astronomy" that "if we represent the orbit of the Earth by a circle of 100 inches radius, the Moon would only move out and in a quarter of an inch, crossing the circumference 25 times in going once round it." This is a very different arrangement from the satellites of Jupiter and Saturn, which seem to form miniatures of the Solar System.

HYDROID ZOOPHYTES.

By HERBERT INGALL.

FORMERLY the study of Zoophytes could only be carried on at the sea-shore, but now continued observations of many of the lower forms of marine life can be made when far away from the sea by means of a marine aquarium at home: a better knowledge of the conditions under which sea-water can be kept renders it possible to store up subjects for study for many months, or indeed years, at a distance from the coast.

Among the smaller objects of marine life the Hydroid Zoophytes will always claim attention, not only from the beauty of their form but from the interesting and extraordinary changes they undergo during their life-history.

Who has not observed the delicate feathery masses thrown up on the beach after a storm or heavy ground swell—masses often of considerable size, but of an exceedingly fine horny substance—or noticed, when examining some clear weed-fringed pool among the rocks on a bright day, delicately curved white plumes like feathers; or seen among the tufts of weed a fine, brown, wiry-looking branching stem, the tips of the branches terminating with a sort of pink flower, which latter if watched will at intervals be seen to bend and nod? These are some of the Hydroid Zoophytes, which formerly were supposed to be a sort of link between animals and vegetables, but they now are without hesitation placed in the animal kingdom.

Three facts will be noticed in the general plan of growth of the Hydroids. There is first the general and common flesh of the composite animal called the *cænosarc*, which may be in the form of a creeping thread, naked, or covered with a *chitinous* or horny substance, which latter is almost always present in the arborescent or branching forms and serves to support them; or the *cænosarc* may be present merely in the form of a thin filament connecting the separate polyps, but in any case it answers the same purpose, which is the general connection of the whole mass of polyps forming the individual colony, and the circulation and conveyance of nutriment over the whole. Secondly, the *polypites* or flower-like animals, that develop at the ends of the branches in the arborescent forms, or may bud out at any part in those that have the *cænosarc* adherent to stones or shells: these serve to collect and catch food, and even living prey, by means of thread-like arms or tentacles. And, thirdly, the reproductive or sexual buds, called the *gonophores*, in which are developed the elements for the propagation of a new colony: the object so produced is called the *gonozooid*.

I have had under observation for many months a colony of *Podocoryne carnea:* they were obtained at Hastings last September. In passing through the old town I noticed some fresh specimens of Dog Whelk (*Nassa reticulata*) lying in the roadway, and, seeing that they had evidently not long come from the sea (no doubt having been just thrown out of some fishing boat), I placed them in my collecting jar, from which they were transferred the same day to an aquarium at home.

A curious association exists between many of the lower animals quite dissimilar in structure—the connection of Podocoryne with the Dog Whelk (*Nassa*) is almost constant, and the obvious explanation would seem to be that the rough shell and the roving life of this whelk is favourable for the development of the polyps; the scavenging and carnivorous habits of the Dog Whelk must be the means of a much more constant supply of food to the lower animal than it could obtain alone. The presence of an allied form (*Hydractinia*) on shells inhabited by the Hermit Crab, may also be ascribed to similar causes, but it is somewhat singular that they should each keep to their own host; we seldom find Hydractinia on Nassa, or Podocoryne on Pagurus, at least so far as the writer's experience extends.

The Polyps composing the colony form an elegant covering to the somewhat sombre-coloured shell of the mollusc over which they wave about like a delicate feathery veil, the beauty of which is enhanced by the lively habits of the Dog Whelk.

The *Polypites* are of a delicate white colour (presenting the appearance shown in Fig. 1). They are furnished with an opening at the upper end, and eight delicate arms, or tentacles, situated a little below and around the mouth; these serve to arrest any small particle of food or minute animals, and to bring them to the mouth, but it is very probable that many or all of these lower animals are not altogether dependent on the solid food caught by the tentacles; extremely minute organisms are always present in the sea, and they are most likely absorbed by the walls of the digestive cavity. The body of Podocoryne is very extensile (as are also the tentacles), and it is attached at its lower end to the *cænosarc*, a delicate creeping covering of fleshy matter which, in this case, closely follows the indentations and reticulations of the shell, quite avoiding the elevated parts or bosses,

FIG. 1.

which protect the animal from getting rubbed off, as it otherwise would, owing to the violent movements given to the shell at times. By the gradual growth of the *cœnosarc*, and the budding up at intervals, the colony spreads over the shell. Besides the *polypites* there spring at times, more often on the rim of the shell, other curious processes, which although they appear to be of somewhat the same substance as the polyps, never attain their form. They are like *thin curved filaments* and roll and unroll in a most curious and lively fashion; they are probably accessories to nutrition, and act as fishing lines.

The colony may go on increasing in this manner for some time, till it almost covers the object on which it grows; after a time, however, according to conditions (generally in the summer or autumn), many of the *polypites* begin to show little buds just below the tentacles. They appear as an enlargement of the *ectoderm* or outer body of the polyp. (Fig. 2). These are the *gonophores* which develop the motile form or *gonozooid*, whose office is to found a future independent colony. This bud gradually enlarges, till the ectotheca or external covering bursts, and the *gonozooid* or *medusa* form (still attached to the polypites by a narrow stem) unfolds itself. (Fig. 3.) An hour or so of pulsations or contractions of the bell, and the new body breaks from the stem of the parent, and dances away through the water, a lovely translucent bell, the minute structure of which will be better seen in Fig. 4. Here we have a delicate transparent bell, somewhat contracted at the opening, where the rim is bounded by a sort of circular canal. From this at regular intervals proceed eight arms or tentacles, very similar in structure to the tentacles of the polypite, being very contractile and furnished with *nematocysts* or thread cells, which are supposed to have a deadly poisonous and paralyzing action on any living thing touched by them; but this I think is scarcely proved, as the irritating effects, well-known to bathers, in the case of the larger medusæ, may be caused by the mechanical effects of the number of minute threads shot out into the surface nerves of the skin. It has also been constantly observed that small entermostracæ, after being caught and held some time by the tentacula, get free and swim away apparently none the worse. At the base or root of each tentacle will be observed a semi-opaque granular mass; this is called the *ocellus*, and is supposed to be an organ of sense. From the apex, and hanging down into the cavity of the bell (which we may here also observe is partially closed at the bottom by a delicate horizontal membrane called the *vellum*) is a kind of "clapper," which is really the body of the gonozooid, and is called the *manubrium*, at the tip of which is the mouth, furnished with four short fringed lips, which are very sensitive, and constantly in motion. In the walls at the side of the manubrium are developed the ova and spermatozoa for the founding of a new colony of polyps,

Fig. 2.

Fig. 3.

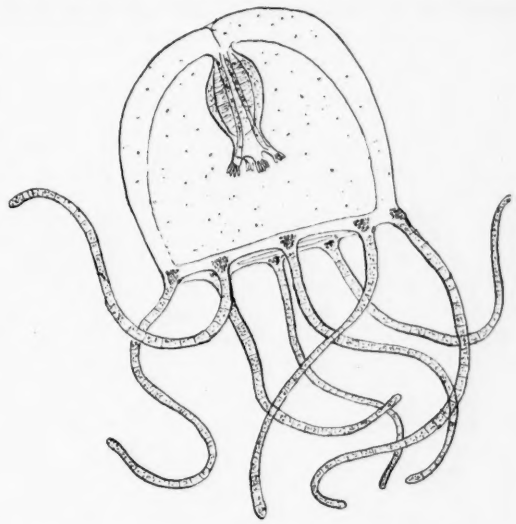


Fig. 4.

and the life-history of the animal is complete. This may be considered as a type of the ordinary history of the *Hydroids*. In general the polypite colony is the permanent form, and the medusoid state the ephemeral one; indeed, one may compare the medusa form of the polyp to the butterfly or the winged aphide, or to the flower on the plant. To quote Van Beneden: "Dans les plantes comme dans les animaux la vie est generalement longue et la tenacité grande dans les individus agames, éphémére et delicate, au contraire, dans les individus sexués. L'ánalogie entre la meduse et la fleur se confirme de plus en plus."

I have taken this particular zoophyte as an illustration of others because it can be easily procured and kept in the aquarium, but the student who wants to see this marvellous life-history of the Hydroids will find abundant variety of other forms. In some of them the gonozooid is of more complex and larger form, but on this occasion I have only described what I have actually seen myself.

THE FACE OF THE SKY FOR SEPTEMBER.

By Herbert Sadler, F.R.A.S.

GROUPS and isolated sunspots are increasing in size and frequency. The following are conveniently observable minima of someA lgol type variables (*cf.* "Face of the Sky" for July): Algol.—September 3rd, 6h. 24m. P.M.; September 20th, 11h. 17m. P.M.; September 23rd, 8h. 6m. P.M. U Coronæ.—September 4th, 10h. 31m. P.M.; September 11th, 8h. 14m. P.M. U Ophiuchi. — September 1st, 7h. 49m. P.M.; September 6th, 8h. 36m. P.M.; September 11th, 9h. 21m. P.M.; September 16th, 10h. 7m. P.M.; September 21st, 10h. 52m. P.M.; September 27th, 7h. 46m. P.M.

Only two planets can be really conveniently observed in September, Venus being in superior conjunction with the Sun on the 18th; Mars, though rising on the last day of the month two hours before the Sun, has too small a diameter (4·0″) to be of any interest to the amateur; Saturn is in conjunction with the Sun on the 13th; and Uranus and Neptune are too near the Sun, as evening and morning stars respectively, to be observed with any profit.

Mercury, though in inferior conjunction with the Sun on the 13th, and therefore invisible during the first half of the month, becomes a striking object in the morning sky during the latter part of September. On the 19th he rises at 4h. 42m. A.M., or 1h. 1m. before the Sun, with a northern declination of 4° 37′, and an apparent diameter of $9\frac{1}{2}''$, about $\frac{1}{10}$ of the disc being illuminated. On the 24th he rises at 4h. 17m. A.M., or about 1h. 33m. before the Sun, with a northern declination of 6° 17′ and an apparent diameter of about 8″, about $\frac{8}{10}$ of the disc being then illuminated. On the 29th he rises at 4h. 13m. A.M., or 1h. 45m. before the Sun, with a northern declination of 5° 33′, and an apparent diameter of $6\frac{3}{4}''$, about $\frac{54}{100}$ of the disc being then illuminated. He is at his greatest western elongation (17° 51′) on the 28th, and during the last three or four days of the month presents pretty configurations with Mars, Saturn, and the Moon (on the last day). While visible he describes a short looped path on the confines of Leo and Virgo, but without approaching any very bright star.

Jupiter is now a magnificent object in the evening sky, being visible all night long. He is in opposition to the Sun on the 5th, being then at a distance of about 369 millions of miles from the earth. He rises on the 1st at 6h. 56m. P.M., with a southern declination of 7° 50′ and an apparent equatorial diameter of 49·2″, and on the 30th at 4h. 54m. P.M., with a southern declination of 9° 12′, and an apparent equatorial diameter of 48·2″. The following phenomena of the satellites occur before midnight, while Jupiter is more than 8° above and the Sun 8° below the horizon. On the 1st a transit egress of the shadow of the second satellite at 8h. 20m. P.M., and a transit egress of the satellite itself at 8h. 31m. P.M. On the 3rd a transit egress of the shadow of the fourth satellite at 10h. 19m. P.M., and of the satellite itself at 10h. 33m. P.M. Before midnight on the 5th all the satellites will be to the west of the planet. On the 6th a transit ingress of the first satellite at 11h. 9m. P.M., and of its shadow one minute later. This transit should be carefully watched, as the satellite will probably be seen projected on its shadow. On the 7th an occultation disappearance of the first satellite at 8h. 24m. P.M., and an eclipse reappearance of the first satellite at 10h. 43m. 25s. P.M. On the 8th a transit egress of the first satellite at 7h. 53m. P.M., and of its shadow five minutes later; a transit ingress of the second satellite at 7h. 57m. P.M., and of its shadow eight minutes later; and a transit egress of the second satellite at 10h. 48m. P.M., and of its shadow ten minutes later. On the 10th a transit ingress of the third satellite at 7h. 31m. P.M., and of its shadow at 7h. 59m. P.M.; a transit egress of the satellite at 10h. 51m. P.M., and of its shadow at 11h. 25m. P.M. On the 14th an occultation disappearance of the first satellite at 10h. 8m. P.M. On the 15th a transit ingress of the first satellite at 7h. 18m. P.M., and of its shadow at 7h. 34m. P.M.; the egress from transit of the satellite at 9h. 36m. P.M., and of its shadow at 9h. 52m. P.M.; a transit ingress of the second satellite at 10h. 13m. P.M., and of its shadow at 10h. 43m. P.M. On the 16th an eclipse reappearance of the first satellite at 7h. 7m. 22s. P.M. On the 17th an eclipse reappearance of the second satellite at 7h. 56m. 20s. P.M.; a transit ingress of the third satellite at 10h. 46m. P.M., and of its shadow at midnight. On the 21st an occultation disappearance of the first satellite at 11h. 53m. On the 22nd a transit ingress of the first satellite at 9h. 2m. P.M., and of its shadow at 9h. 28m. P.M.; a transit egress of the satellite at 11h. 20m. P.M., and of its shadow at 11h. 47m. P.M. On the 23rd an eclipse reappearance of the first satellite at 9h. 2m. 37s. On the 24th an occultation disappearance of the first satellite at 6h. 45m. P.M., and its reappearance from eclipse at 10h. 31m. 51s. On the 26th all the satellites will be to the west of the planet. On the 28th an eclipse disappearance of the fourth satellite at 8h. 6m. 53s., and reappearance at 11h. 48m. 19s.; an eclipse reappearance of the third satellite at 9h. 20m. 7s. On the 29th a transit ingress of the first satellite at 10h. 47m. P.M., and of its shadow at 11h. 23m. P.M. On the 30th an eclipse reappearance of the first satellite at 10h. 57m. 57s.

There are no well-marked showers of shooting stars in September.

The Moon is new at 8h. 16m. A.M. on the 2nd; enters her first quarter at 11h. 7m. A.M. on the 11th; is full (Harvest Moon) at 5h. 4m. A.M. on the 18th; and enters her last quarter at 11h. 7m. P.M. on the 24th. She is in apogee at 8·2h. P.M. on the 4th (distance from the earth 252,610 miles), and in perigee at 6·4h. A.M. on the 18th (distance from the earth, 221,720 miles). Her greatest eastern libration is at 5h. 15m. A.M. on the 12th, and her greatest western at 8h. 5m. A.M. on the 24th.

This is a very remarkable Harvest Moon, as the Moon attains her perigee less than an hour and a half after she is full, and her approach to the earth is one of the closest possible, the minimum distance at perigee being, according to Neison, 221,614 miles.

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

TO CORRESPONDENTS.—Communications for this column should be addressed "C. D. LOCOCK, *Cintra, Hawkhurst, Kent*," and posted *before* the 10th of each month.

SOLUTION OF PROBLEM No. 2 (*by G. F.*): 1. Q to KKt2 :—

1. . . R to KKt8 (or Kt checks)	2. K to B7, etc.
1. . . Kt × Kt	2. Q to Kt3 ch, etc.
1. . . R to Q R 4	2. Kt to K4 ch, etc.

The words "White" and "Black" were accidentally transposed on the diagram. Fortunately the mistake was one which, if noticed, should easily be suspected.

CORRECT SOLUTIONS from :—Alpha, K, M. B. (Jesmond), C. S., W. T. Hurley, R. W. Houghton, E. B., C. T. Blanshard, Giu. Pianissimo, T. A. Earl, T. E. Kerrigan, W. E. B., F. R., J. Landau, R. T. M., A. Rutherford, T., J. Taylor—(18 correct; 4 partly incorrect).

Alpha. — First again, according to your prerogative. Your criticisms are just. No. 2 is, the composer tells us, his third attempt only.

Betula.—You are wrong in giving *two* continuations for White after 1. . . R to R4, and again after 1. . . Kt × Kt, *e.g.*, 1. . . R to R4; 2. K to B7 (?), R to KB8; 3. No mate. Or 1. . . Kt × Kt; 2. K to B7 (?), Kt to K5; 3. No mate. Hence the deduction of four points. Your problem, though simple, is neat and artistic. With ties in prospect, it may be necessary to defer its insertion till after the tourney closes.

A. C. L. W.—If 1. . . Kt × Kt; K to B7, Kt to K5; 3. No mate. This loses two points.

G. F.—Omitting R at QR8 does away with variation 3. Omitting the other Rook permits a dual in the same variation. The White Pawn at KR3 instead of Black Pawn at KR7 would be an improvement. Thanks for the game, for which room may be found soon. Glad you like the articles.

C. S.—Could you not find another first move? A determination to do so might lead to other improvements in construction.

H. W. P.—Solution of problem No. 1 posted July 23, and cannot therefore count in the competition, being a fortnight beyond the limit.

J. Johnston and *T. H. Billington* (Wolverhampton).—See first part of answer to "Betula." By a curious coincidence you both give in two variations 2. Q to B3 ch. (obviously a misprint for Q to Kt3 ch.). No deduction has been made for this.

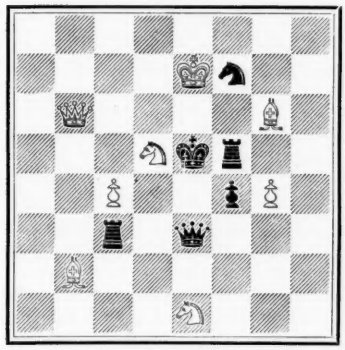
T. H. B.—Thanks for problem, which shall be examined.

J. J.—With the exception of the key-move, your solution is totally incomprehensible. In some of your variations the White Pawns move in the same direction as the Black.

PROBLEM (No. 3).

By C. D. L.

BLACK.



WHITE.

White to play, and mate in two moves.

SOLVERS' SCORES.

Alpha	11	J. Taylor	11
W. E. B.	11	A. C. L. Wilkinson	9
T. E. Kerrigan	11	T. H. Billington	9
W. T. Hurley	11	Betula	7
K.	11	J. Johnston	3
Giu. Pianissimo	11	A. G. Hansard	3
T. A. Earl	11	T. K. Bentley	3
F. R.	11	F. W. Sharp	3
R. W. Houghton	11	White Knight	3
G. F.	11	A. J. Luisham	3
E. B.	11	J. Humble	3
C. S.	11	A. N. Brayshaw	3
M. B. (Jesmond)	11	R. A. Layton	3
C. T. Blanshard	11	J. G. Ellis	3
R. T. M.	11	H. C. H.	3
J. Landau	11	H. S. B.	0
A. Rutherford	11	F. de F.	0
T.	11		

Scores under 6 will be omitted in uture.

CHESS INTELLIGENCE.

THE COUNTIES CHESS ASSOCIATION held its meeting at Oxford during the first week in August. In the principal tournament a tie resulted between Mr. J. H. Blake, of Southampton, and the Rev. A. B. Skipworth, the Hon. Sec. of the Association. Their scores were the high ones of $7\frac{1}{2}$ out of a possible 9. Other scores were necessarily low, the Rev. J. Owen and Messrs. Trenchard, Lambert and Jones-Bateman being equal with $4\frac{1}{2}$. Mr. Thorold was half a point behind. The tie for first prize and possession of the challenge cup will be played off in London, probably in October. Mr. Blake having been successful "in the personal encounter" (to use Mr. Steinitz's expression) will be perhaps slightly the favourite.

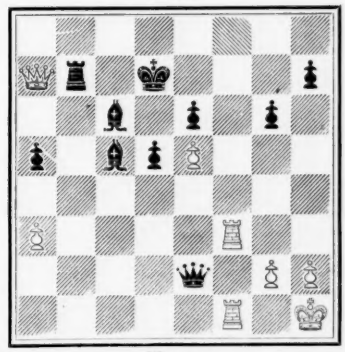
Game played in the Divan Tournament:—

FRENCH DEFENCE.

	WHITE. (R. Loman.)	BLACK. (N. Jasnagrodsky.)
1.	P to K4	P to K3
2.	P to Q4	P to Q4
3.	QKt to B3	KKt to B3
4.	P to K5	KKt to Q2
5.	P to B4	P to QB4
6.	P × P	Kt to QB3 ! (*a*)
7.	Kt to B3 (*b*)	Kt × P ? (*c*)
8.	B to Kt5	B to Q2
9.	Castles	P to QR3 (*d*)
10.	B × Kt	P × B
11.	K to Rsq (*e*)	B to K2
12.	Kt to Q4	Kt to Kt2 (*f*)
13.	Q to Kt4	P to Kt3
14.	B to Q2	P to QB4
15.	KKt to K2 (*g*)	Kt to R4
16.	QR to Ksq	R to QKtsq
17.	B to Bsq	Kt to B3
18.	Q to R3 (*h*)	Kt to Kt5
19.	P to QR3	Kt × P
20.	R to Qsq	Kt to R8
21.	P to B5 !	Kt to Kt6 (*i*)
22.	P × P	BP × P
23.	B to R6	B to R5 (*j*)
24.	R to B3 (*k*)	R to Ktsq (*l*)
25.	QR to KBsq	B to K2
26.	Q to Kt4	Kt to Q5
27.	Kt × Kt	P × Kt
28.	Q × QP (*m*)	Q to Kt3
29.	Q to KB4	B to B3 (*n*)
30.	B to B8 !	R × B
31.	Q × Rch	K to Q2
32.	Q to B4 (*o*)	P to QR4 ? (*p*)
33.	Kt to R4	Q to Kt4
34.	P to QKt3	Q to K7 (*q*)
35.	Q to Q4	R × P
36.	Q to R7ch	R to Kt2 (*r*)
37.	Kt to B5ch	B × Kt

Position after Black's 37th move.

BLACK.



WHITE.

White mates in six moves by

38.	R to B7ch	B to K2
39.	R × Bch ! (*s*)	K × R (*t*)
40.	Q to B5ch, and mates in three more moves.	

NOTES.

(*a*) Much better than either 6. . . . B × P; 7. Q to Kt4, or 6. . . . Kt × P; 7. B to K3, or 7. Kt to B3. Delaying the capture puts White in a dilemma, for he cannot tell how the Pawn will be taken.

(*b*) If 7. Q to Kt4 ?, Kt × BP; 8. B to K3, P to Q5; 9. Castles, Q to Kt3! winning the exchange. 7. P to QR3 is sometimes played, and has the merit of compelling Black to show his hand (otherwise White will defend the Pawn by P to QKt4), but does not in other respects aid development. We would suggest 7. B to K3, as the safest continuation, but disbelieve in the whole attack. Mr. Loman's move is of doubtful value, shutting out, as it does, the Q from Kt4.

(*c*) For Black could now hamper development considerably by B × P. White now hastens to Castle while he can.

(*d*) A lost move; the Bishop is quite harmless. He should play either 9. . . . B to K2, or 9. . . . Q to Kt3; for if then 10. B to K3, Kt × P!; 11. Kt × Kt, B × B; 12. P to QKt4, B × R; and though White gets some attack by retaking the Bishop at once, it should be parried by careful play.

(*e*) Kt to Q4 might be played at once.

(*f*) Castling is much better. If then 13. Q to Kt4, P to KB4, followed by Kt to K5, and P to QB4 if the Queen moves.

(*g*) Perhaps Kt to B3 is preferable, leaving K2 for the other Knight.

(*h*) The key-move of an ingenious plan for breaking through on the King's side.

(*i*) If KtP × P, 22. B to R6, Kt to Kt6; 23. B to Kt7 wins.

(*j*) The only move. If 23. . . . R to Ktsq, 24. Q to B3, B to QBsq.; 25. Q to B7ch, and 26 Kt × P.

(*k*) Or 24. Q to B3, Q to K2; 25. P to Kt3 (not 25. R × P ?, P × R; 26. Kt × P, B to B3!).

(*l*) To prevent B to Kt7 after the next move on each side. The best defence, however, is probably B to Bsq.

(*m*) If 28. Q to B4, B to Kt4! Not 28. . . . QB to Bsq; 29. Q to B7ch, K to Q2; 30. Kt × P, &c.

(*n*) Overlooking White's brilliant reply. K to Qsq. was the only move.

(*o*) Best. If Q to Kt7 Black can safely take the KtP.

(*p*) Not to much purpose, Probably his best chance of drawing lay in R to KBsq., in order to remain with two Bishops against a Rook and Knight.

(*q*) Baiting a trap to catch himself.

(*r*) If K to Ksq. White forces the game by 37. R to B8ch, B × R; 38. Q to B7th, 39. Q × Bch, and 40. Q to Q6ch, mating in a few moves, or winning the Queen. The variations are worth following out.

(*s*) A very brilliant termination.

(*t*) If K to Qsq mate follows in three moves by R to B8ch, etc.

KNIGHTS AND BISHOPS.

(*Continued from p.* 160.)

4. A Bishop acts *at a distance*. This power is of great importance in attacking the adverse King. To take a simple instance: A Bishop checks a King; the King can never move so as to gain time by attacking the Bishop in turn. On the other hand, when checked by a Knight the King has *two* squares available for coming in contact with the attacking piece. Take again the case where a Knight is used to defend a single Pawn in the end-game. The adverse King (or Queen) by attacking both at once wins one or the other. A Bishop in a similar situation would simply move away, still holding on to the Pawn. Hence we get the corollary that in *defending* Pawns a Bishop is superior to a Knight; in *attacking* them the case is reversed (*vide* point 2).

5. Again, in the end-game a Knight is inferior to a Bishop in the art of *stopping* passed Pawns. Imagine a diagonal series of six Pawns extending from Black's QKt2 to his KKt7. A White Bishop, by simply occupying the diagonal in front, effectually stops the whole six from advancing. A Knight would be helpless against more than *two* of the six. In the case of a single adverse passed Pawn advancing to Queen, it is obvious that, while a distant Knight will have to start at once in order to catch it, a Bishop may quietly wait until the Pawn has reached the sixth or seventh row. This is owing to the superior *pace* of the Bishop.

6. A Bishop can *gain a move*, *i.e.*, it can take, if necessary, an *odd* number of moves to leave and regain the square which it occupies. This is sometimes of importance in the end-game, and here again the Knight is at a disadvantage, the process mentioned invariably taking an *even* number of moves.

7. A Bishop can *confine* a Knight at the side of the board. This, of course, will seldom occur except in the end-game.

8. A Bishop "pins"; a Knight "forks." The latter is, we think, by far the more dangerous gift. There are more opportunities for its exercise, and there is no "interposing" against a "fork." The summing-up and verdict must be deferred till the next number.

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